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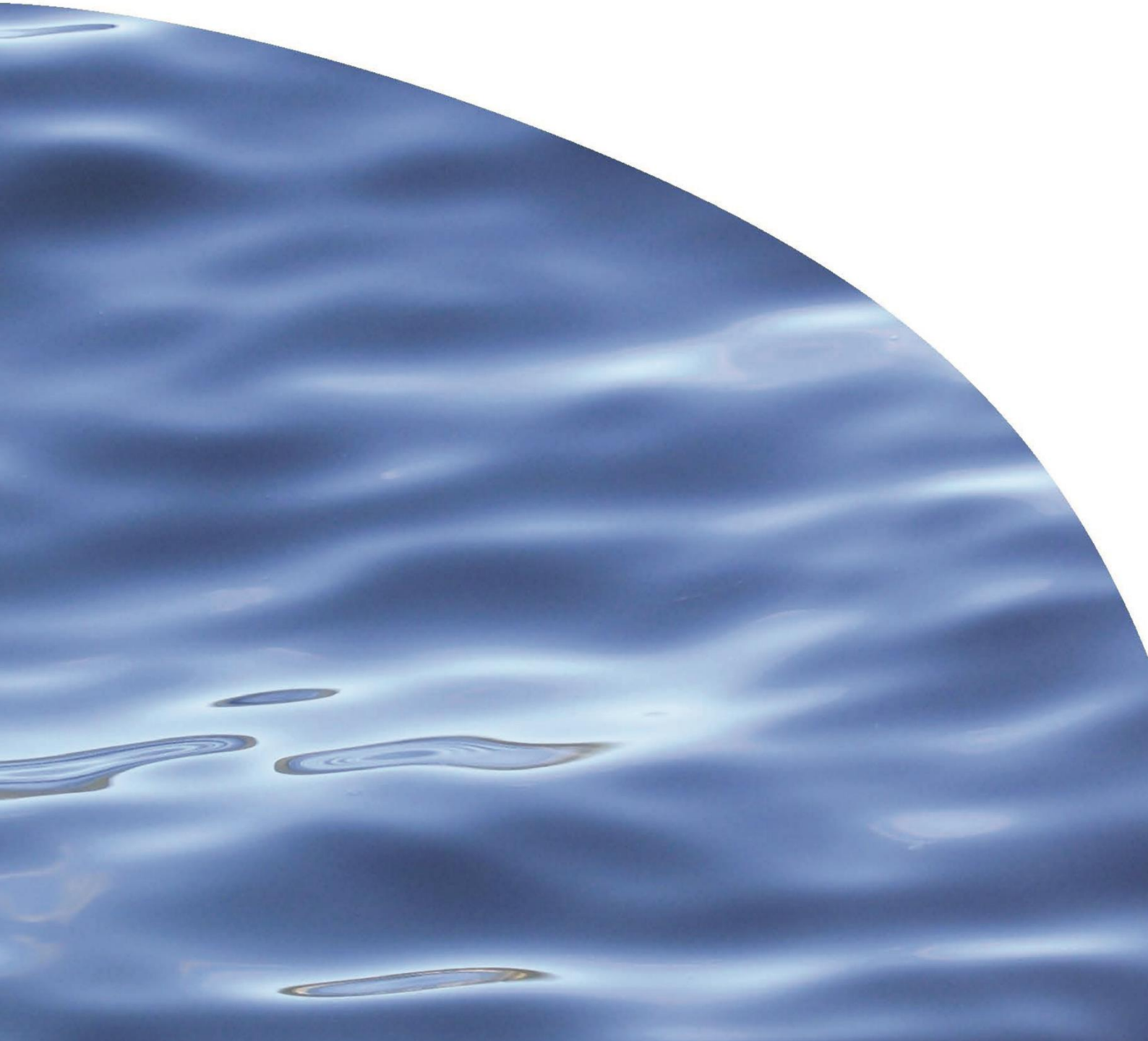
SECOND BASELINE ECOLOGICAL TRANSECT SURVEY OF PANIA REEF



SECOND BASELINE ECOLOGICAL TRANSECT SURVEY OF PANIA REEF

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Prepared for Port of Napier Ltd

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EXECUTIVE SUMMARY

Port of Napier Limited (PONL) plans to deepen its existing approach channel to accept deeper draft vessels and establish a new berth (No.6 berth) on the northern face of the main Port reclamation. As part of the resource consents covering capital dredging and spoil disposal, PONL was required to complete a baseline ecological dive survey of Pania Reef. In addition, under a Heads of Agreement between PONL and Legasea Inc., there was an undertaking to provide a baseline visual survey and photographic record of the existing habitats and the sediment and turbidity characteristics of Town Reef.

This report describes the methodology and findings of the combined Pania and Town Reef surveys, conducted over 24–26 May 2019. The survey of Pania Reef follows an earlier survey of the reef completed in 2016 that was associated with the assessment of effects from the project. Since both Pania Reef surveys have used identical transect locations and methodology, the current survey essentially provides a second baseline dataset.

The surveys comprised a series of 100 m diver transects of the seabed, eight on Pania Reef and three on Town Reef. For the Pania Reef transects, divers employed video and quadrat photography, with the presence and relative abundance of conspicuous biota recorded on underwater field forms. Additional close-up photographic images were collected using compact cameras and all data was bracketed into 10 m segments of the transect. The Town Reef transects employed only video and compact underwater cameras to document seabed communities and conditions.

As baseline characterisations of the reef communities, this is essentially a data report. It establishes an inventory of conspicuous reef biota and examines the spatial variability of community composition, with a focus on gradients along the Pania Reef axis. Some comparison with the data from the earlier 2016 survey is provided as an indication of longer-term temporal variability. Generally, a high degree of consistency was evident between results from the two Pania surveys although small but consistent changes were noted for a few taxa that could be considered characteristic of the Reef.

A spatial gradient in encrusting reef communities was observed along the reef axis. This included greater incidence of a range of sponges, ascidians and several cnidarians towards the southern (inshore) section of the reef and a lower incidence of two of the more generally abundant bryozoans.

Benthic communities observed at Town Reef were generally consistent with those recorded for nearby south Pania Reef. Since both the turbidity and depositional conditions found at Town Reef represent a snapshot in time, caution must be exercised regarding assumptions of variability. However, the compiled taxa inventory and photographic record represent a sound basis from which to assess change in reef communities over time.

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GLOSSARY

Item	Description / meaning	Category
A	Abundant - an abundance category	Abbreviation
C	Common - an abundance category	Abbreviation
cf.	Compare. In taxonomy used to express a possible identity, or at least a significant resemblance.	Abbreviation
cm	Centimetre	Unit
g	Grams	Unit
GPS	Global Positioning System	Acronym
ha	Hectare	Unit
HOA	Heads of Agreement	Acronym
km	Kilometre	Unit
m	Metre or metres	Unit
MBES	Multibeam echo-sounder	Acronym
O	Occasional - an abundance category	Abbreviation
PONL	Port of Napier Ltd	Acronym
R	Rare - an abundance category	Abbreviation

1. INTRODUCTION

1.1. Background

Port of Napier Limited (PONL) plans to deepen its existing approach channel to accept deeper draft vessels and establish a new berth (No.6 berth) on the northern face of the main Port reclamation. This will entail widening the current dredged channel and extending it seaward by approximately 1.3 km. The swing basin at the Port entrance will also be extended approximately 120 m westward and 220 m southward and deepened to serve the new berth. Over multiple stages, the dredging project will generate approximately 3.2 million m^3 of dredge spoil and this will be deposited in a consented 346-ha disposal area located approximately 3.3 km south-east of Pania Reef and 4 km offshore in water depths of 20-23 m. The spatial footprint for the dredging work and the proposed disposal area for the dredge spoil, in relation to the principal features of the coastline, are depicted in Figure 1.

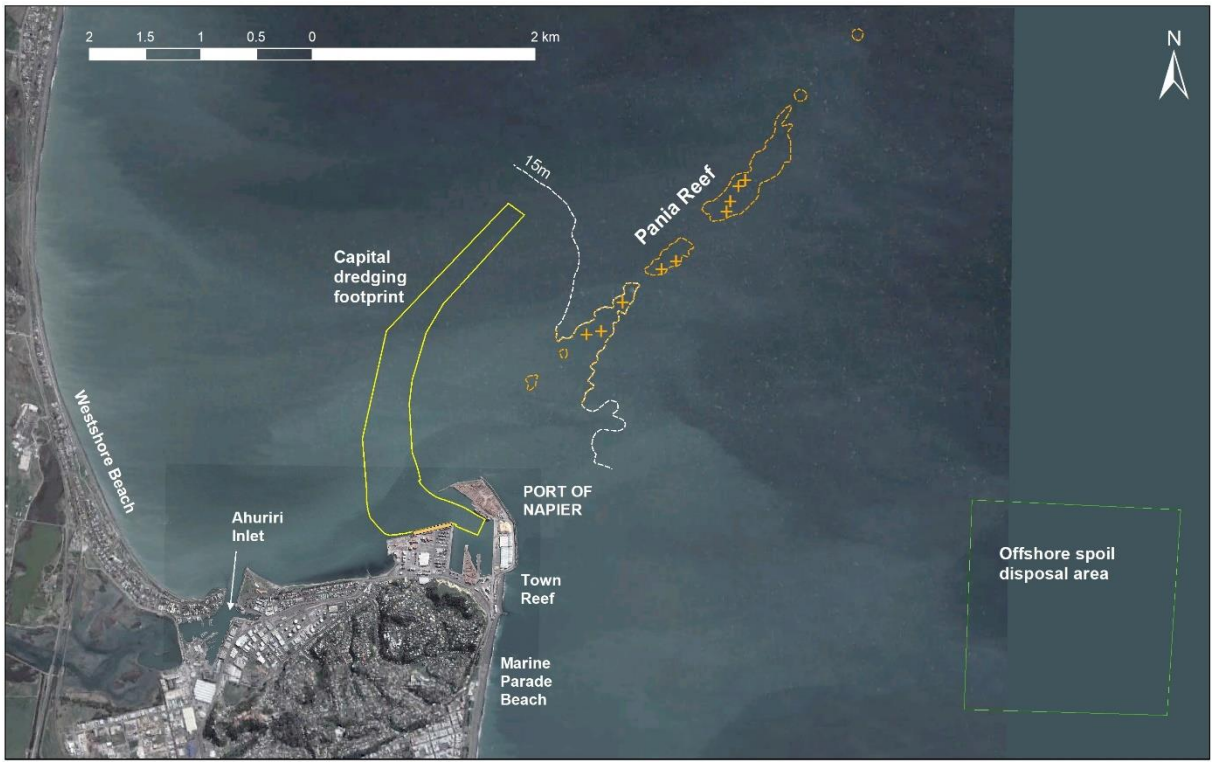

Figure 1. Composite aerial photograph of Port of Napier, showing the scale and layout of the proposed project elements.

1.1.1. Pania Reef

Pania Reef is the major seabed feature in southern Hawke Bay (Duffy 1992). It extends in a north-easterly direction beginning approximately 800 m from the Port of

Napier. It is widest (~400 m) at the south-western end, approximately 1 km northeast of the main Port breakwater, where the boulder and rock substrate emerges gradually from a 15 m deep sand bottom. Toward the seaward end, the topography becomes progressively steeper with large rocks, fissured with crevices, protruding from a sandy seabed at 18 m water depth.

At its closest points, the Reef is approximately 0.9 km south-east of the capital dredging footprint and 3.3 km north-west of the proposed offshore spoil disposal area (Figure 1). As part of the assessments conducted for the project resource consent application, the ecology of the Reef was surveyed in May 2016 (Sneddon et al. 2017). Consent for the dredging project was granted in November 2018, imposing requirements on PONL to complete additional monitoring on Pania Reef over the course of the project, including a second baseline survey.

1.1.2. Town Reef

Town Reef is located adjacent to the base of the main Port breakwater at the northern end of Marine Parade Beach (Figure 1). It represents the inshore section of a formerly continuous reef system with Pania Reef. It is approximately 2 km to the south of the proposed Fairway capital dredging operations and 4 km from the offshore spoil ground. Like Pania Reef, it is a relatively well-flushed, high-energy environment due to exposure to both wave action and along-shore currents.

In addition to the surveys of Pania Reef, there is a requirement, under a Heads of Agreement (HOA) between PONL and Legasea Inc., to provide *a baseline visual survey and photographic record of the existing habitats and the sediment and turbidity characteristics of … Town Reef.*

1.2. Scope

This report describes ecological survey work undertaken to meet the requirements of condition 11 (f) of Resource Consent CL180009E to complete a dive survey of Pania Reef within 6 months of commencement of the consent (27 November 2018). It also covers survey work at Town Reef required by the HOA between PONL and Legasea.

The principal approach to the survey of Pania Reef was set by methodology established for the 2016/17 assessment that accompanied PONL's consent application (Sneddon et al. 2017). While this is essentially a data report, some interpretation of differences between the current and earlier survey results is provided.

The approach used to characterise the ecology of Town Reef was more qualitative, with an emphasis on the photographic record; however, an inventory of taxa observed along each of the three Town Reef transects was generated.

2. METHODS

The surveys of Pania and Town reefs were undertaken over 24-26 May 2019 by four Cawthron Institute scientific divers from the 7.8 m alloy work boat *FinFinder*. All transect lines were laid according to GPS waypoints and compass bearings. The weighted transect line was tagged at 10 m intervals along its length. The transects were set up by dropping the weighted end of the transect line at the established start waypoint (generally a point on or near the reef crest) and running the remaining length of line out towards the finish waypoint until taut, from where the deeper end was lowered on a second weighted shot line.

2.1. Pania Reef

The Pania Reef survey utilised eight 100 m-long dive transects spaced out along the length of the reef (Figure 2). The locations of these transects were identical to those surveyed in March 2016 and described in Cawthron Report 2895 (Sneddon et al. 2017). Prior to the 2016 survey, transects PR1, PR2, PR3 and PR4 were also surveyed in 2005 (Cawthron unpublished data). Transects PR1 and PR2 were, in turn, located according to those surveyed by Duffy (1992). Two divers descended to the deepest point of the transect then swam along the transect line, one recording notes on the presence and relative abundance of conspicuous biota, the other taking quadrat photographs and recording video.

At each of the 10 m interval marks along the transect, five 41 cm x 61 cm (0.25m^2) rectangular photoquadrats were taken using a 10-megapixel digital SLR camera attached at a fixed distance from the quadrat. One was taken at the transect line distance tag, while the remaining four were taken within the four compass sectors around it at a radial distance of approximately one metre. Between each of the 10 m distance tags, video footage was collected using a GoPro Hero camera.

The second diver compiled ecological notes using a field sheet template based on the reef habitat / taxa inventory established by the previous survey in 2016 (Sneddon et al. 2017). A separate record was compiled for each 10-m section of the transect within a 2-m band (1 m each side of the transect line). Each record included water depth, habitat / substratum type, and the relative abundance / percentage cover of algal and faunal species, including fish as well as conspicuous surface-dwelling or encrusting organisms. Abundance / coverage data were entered using a categorical scale, ranked subjectively as ‘rare’, ‘occasional’, ‘common’, or ‘abundant’. Guidelines used for these abundance categories are listed in Table 1. This information was used to compile a description of the habitat and the community of epibiota[1] occurring at these locations on the reef.

[1] Organisms living on or above the substratum surface.

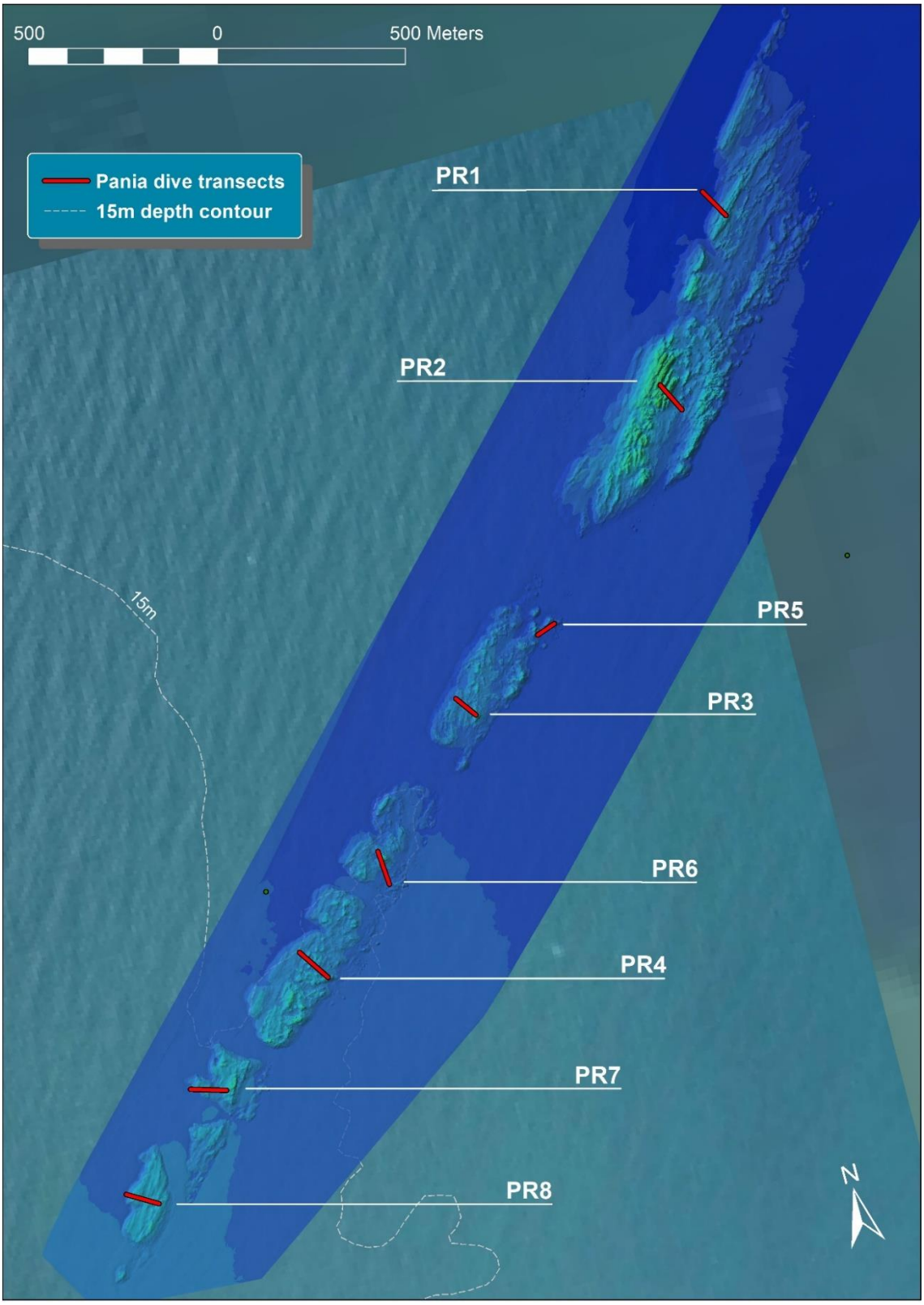

Figure 2. Multi-beam Echo-Sounder (MBES) image of Pania Reef showing locations of survey transects.

Table 1. Description of the categorical scale used to survey the intertidal sites.

Category	Rank value	Description
Absent	0	
Rare	1	1–2 individuals, or a single cluster or patch of individuals in one small area (e.g. small patch of sponge or algae)
Occasional	2	3–10 individuals throughout the area of assessment
Common	3	> 10 individuals throughout the area of assessment
Abundant	4	Individuals abundant enough to form a distinct zone or habitat (e.g. mussels, barnacles and some algae), or hundreds to thousands of individuals per m^2.

Both divers also used compact hand-held cameras to collect additional close-up imagery of biota. To avoid reflection interference from suspended particulates, strobe illumination was not used for the compact camera images. Due to the ability to see additional detail in these close-up photographs of encrusting communities, a careful review of the photographic and video record was used to augment the abundance record, although taxa added to the transect record in this way were flagged as such.

2.1.1. Data analysis

To analyse the compiled relative abundance data for each transect, the categories were converted to numerical values according to the assigned rank values listed in Table 1. Summations of these values across the ten 10-m intervals for each transect gave a total score for each taxon. These could then be compared across the eight transects and between the two surveys to evaluate spatial and temporal variability.

2.2. Town Reef

Three transects were surveyed at Town Reef. These were arranged spatially to cover three shallower areas of reef substrate marked on nautical chart NZ5712a (Figure 3). The focus at Town Reef was on compiling a comprehensive photographic and video record along each transect[2].

[2] Due to sea-condition constraints at this nearshore location (especially turbidity), it is considered unlikely that quantitative aspects (such as abundance and cover) will always be able to be accurately and reliably recorded in repeat surveys.

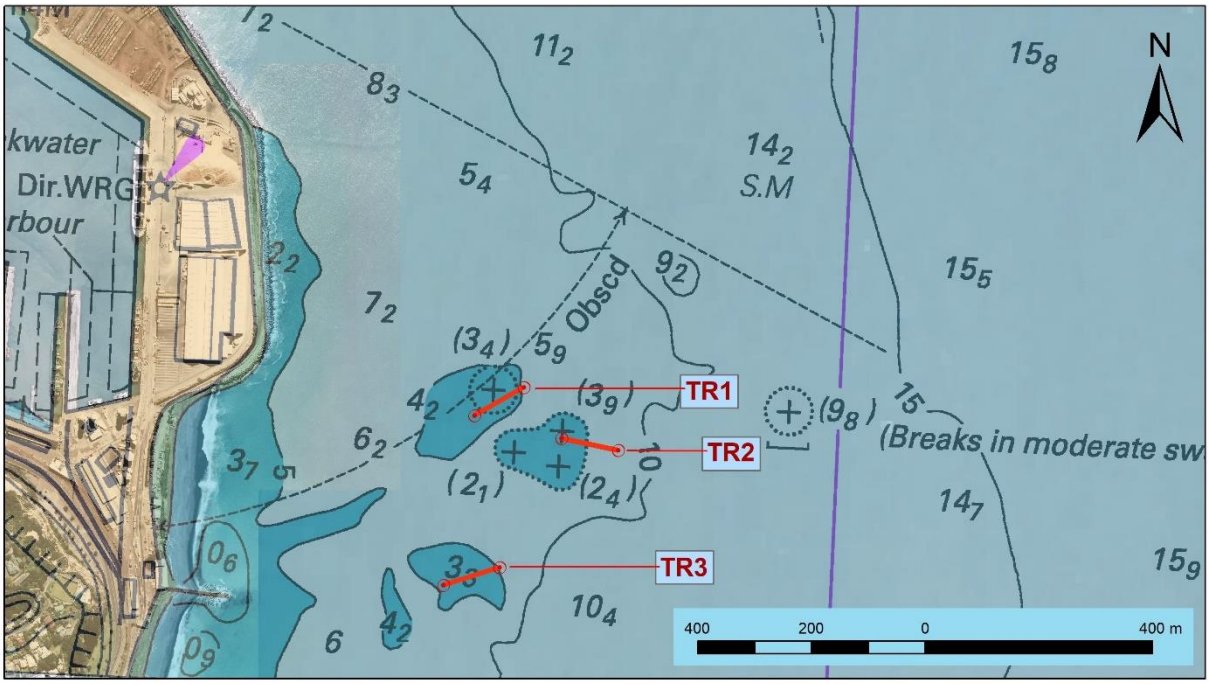

Figure 3. Locations of the three Town Reef dive transects (bold red lines), overlaid upon part chart NZ5712a.

The two divers were each equipped with a compact hand-held camera and one with an additional GoPro underwater video camera. The divers swam on either side of the transect line, recording biota and substrate within approximately 2 m of the line. This resulted in the record representing a 4 m wide swathe. Photographs were taken of each 10 m distance tag, thereby bracketing the photographs into distance intervals along the transect. By having the divers cover the transect at an approximately constant speed, the depth record from their wrist-mounted computers could later be used to generate a depth profile for the transect.

On completion of the dive, additional notes were compiled on the prevalence of the major fauna and flora and the nature of the habitats observed. By reviewing the photographs and video, these notes could later be expanded into a descriptive characterisation of reef habitats and communities.

3. SURVEY RESULTS

3.1. Pania Reef transects

3.1.1. Notes on underwater photographs

As was the case during the 2016 survey, underwater visibility was sometimes problematic for quadrat photography. Suspended particulate matter between the lens and the subject invariably obscured some detail and this was exacerbated by some particulate-reflected light from the strobes, even though these were offset from the camera. For this reason, the quadrat photographs are of only limited use for identification of any but the most conspicuous organisms. Use of a hand-held compact camera by each diver enabled the collection of clear images at close range. While these don't always indicate the wider habitat characteristics, shots of transect distance tags allowed the bracketing of images to within each 10 m section. Taken together, the two photographic image sets are complementary, providing a comprehensive record of the habitats and conspicuous biota occurring along each transect.

3.1.2. Description of habitats and communities

The following sections present descriptions and graphics that characterise the communities and habitats along each transect. These were generated from diver notes and a review of the photographic and video record. Each table summarises the findings from 2016 and augments this with additional detail from the current survey and comment on where notable differences occurred. Where applicable, brief comparative notes on the 2005 survey results (transects PR1, PR2, PR3, PR4) are also provided. Transects are given in their physical order (Figure 2), not numerical.

The associated figures depict the transect depth profile, generated from diver-recorded depths at each of the 11 transect distance tags. The profile is compared in each figure with that recorded during the 2016 survey. Neither profile has been adjusted for tidal variation (tidal range on the order of 1–1.5 m at Napier), hence they should be interpreted as indicative only. In places, the Reef has very uneven bathymetry over small spatial scales and exact transect line placement along its entire length is impossible. Therefore, the comparison serves as a check on transect consistency between the two surveys and assists with interpretation of the ecological data where locally significant differences in profile have occurred.

A series of eight photographs (a mix of quadrat and compact camera close-ups), were selected as representative of substrate, habitats and biota, and these are shown located along each transect profile. Photographs were post-processed with colour-balancing software to increase contrast and bring out detail (see discussion in Appendix 1). For this reason, the colour in some photographs presented in the transect figures may appear oversaturated and they do not necessarily indicate the visibility and colour observed by the divers.

Dive Transect PR1

Dive transect PR1 is situated on the northern end of the reef system. It begins at a depth of 20 m and ran in a south-easterly direction to finish at a depth of 12 m (Figure 4).

	2016	2019
SUBSTRATE	The first 60 m of the transect comprised undulating bedrock overlaid with sand and fine silt. From 60 m onwards along the transect, the reef typography steepened and kelp (*Ecklonia radiata*) forest became the dominant habitat. Although there was less silt, small amounts were still observed amongst the sessile epibiota.	The same substrate mix of bedrock overlain with sand in the deeper sections. Sand appeared slightly more prevalent throughout the transect except for the last 20 m, which (as in 2016) were bedrock only.
EPIBIOTIC COMMUNITIES	27 taxa recorded. The ecological community in the first 60 m comprised a variety of sessile invertebrates, the most prevalent being the orange finger sponge (*Raspalia topsenti*), the yellow tubular sponge (*Ciocalypta* sp.), a hydroid (bushy hydroid [*Hydrozoa* sp.]), clowns-hair bryozoan (Catenicellidae sp.) and erect bryozoan (cf. Candidae sp. A). Smaller organisms such as sea tulip (*Pyura spinosissima*), stony coral (*Culicea rubeola*), white striped anemone (*Anthothoe albocincta*), siphon whelk (*Penion sulcatus*), hermit crab (*Pagurus* sp.) and sea cucumber (*Australostichopus mollis*) were also present in low numbers. The red alga *Plocamium cirrhosum* was the only macroalga present. From 60 m onwards along the transect, kelp (*Ecklonia radiata*) forest became the dominant habitat. Many crevices and holes provided habitat for a plethora of sessile invertebrates including the grey massive sponge (*Ecionemia alata*), pink encrusting coralline paint (*Corallinales*), saddle squirt (*Cnemidocarpa* sp.), an unidentified bivalve, clowns hair bryozoan and orange finger sponge. As the profile became shallower (< 15 m depth), large patches of green-lipped mussels (*Perna canaliculus*), along with gastropods such as the green top shell (*Coelotrochus viridus*), tiger shell (*Calliostoma tigris*) and Cook's turban (*Cookia sulcata*) were also present amongst the kelp. The sponge communities remained present in the troughs and under the overhangs.	39 taxa recorded. The pattern of distribution along the transect was consistent with that of 2016. As in 2016, only the kelp *E. radiata* was recorded as abundant (in depths shallower than 14 m). Species most often recorded as common were the orange erect bryozoan (*Steginporella*), encrusting bryozoans, clowns hair bryozoan, three sponges (*Ciocalypta*, *E. alata* and *Cliona* sp), coralline paint and green-lipped mussels (the latter two in depths shallower than 14 m). The only newly recorded alga was *Carpomitra costata* (single incidence only). Newly recorded sessile invertebrates (transect abundance score ≥ 3) were encrusting bryozoans, orange encrusting sponge (cf.*Tedania* sp.) and *Cliona* sp. Taxa consistently recorded as present (occasional or rare) throughout three or more sectors included the orange finger sponge (*R. topsenti*), the red alga *P. cirrhosum*, branching bryozoans, the clown nudibranch (*Ceratosoma amoena*), the siphon whelk (*P. sulcatus*) and the stony coral (*C. rubiola*). Fine branching hydroids were absent from PR1 despite being recorded as common to occasional through the middle sections of the transect in 2016 (abundance score 11). This taxon was consistently present, however, in the more inshore transects (PR4, PR6, PR7, PR8).

	2016	2019
FISH	9 species recorded. Numerous demersal and semi-demersal fish species were encountered along the transect including blue cod (*Parapercis colias*), dwarf scorpion fish (*Scorpaena papillosa*), and a variety of triple fins (common [*Fortserygion lapillum*], variable [*Forsterygion varium*] and yellow-black [*Forsterygion flavonigrum*]). In the water column were butterfly perch (*Caesioperca lepidoptera*), leatherjackets (*Meuschenia scaber*), scarlet wrasse (*Pseudolabrus miles*) and spotted wrasse (*Notolabrus celidotus*).	7 species recorded. The species mix was consistent between surveys. Although recorded, butterfly perch (*C. lepidoptera*) and triplefins were notably less prevalent in 2019.
NOTES	Ecological communities in the earlier 2005 survey of this transect were similar although a notable difference was the absence of flap jack (*Carpophyllum maschalocarpum*) in 2016. This was considered to be due to the slightly deeper depth (≤ 12 m) of the 2016 transect (surface-operated video footage confirmed the presence of flap jack at shallower depths near this station).	Good visibility (2–3 m). *C. maschalocarpum* was again absent from the transect in 2019.

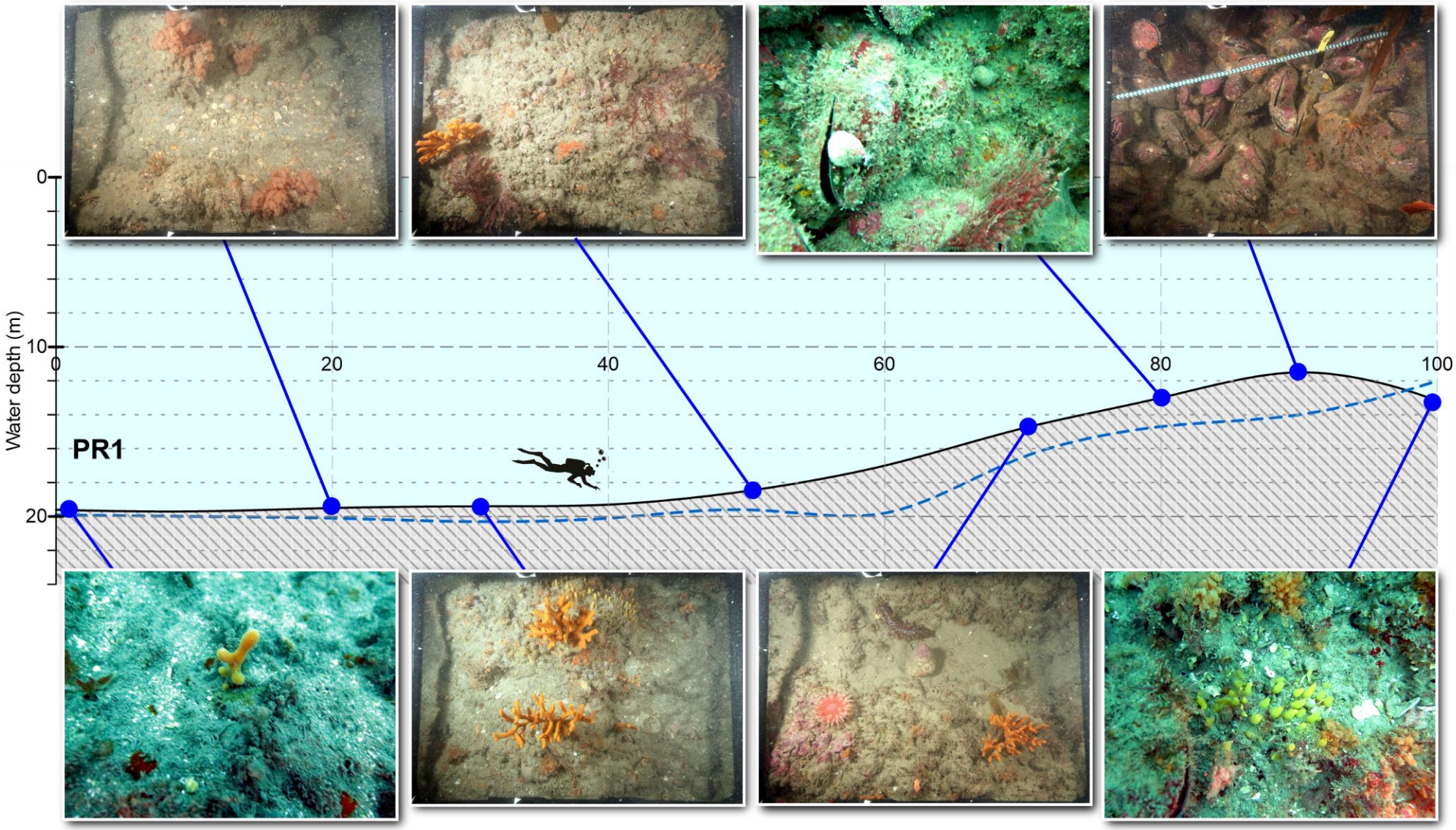

Figure 4. Depth profile with photographs of representative habitat along PR1. The photographs are aligned with the transect profile to indicate representative habitat along the transect and the blue lines indicate the location at which they were taken. Blue dashed line represents the depth profile recorded during the 2016 survey. Grey dashed line and numbers show distance along transect.

Dive Transect PR2

PR2 is located on the south west side of Pania Rock. The transect begins in 14 m water depth and progresses in a north-westerly direction towards the top of Pania Rock at 4 m depth (Figure 5).

	2016	2019
SUBSTRATE	The substrate along the first 10 m of the transect comprised bedrock covered in sand patches and a fine layer of silt, after which there was a mix of cobble, boulder, bedrock and sand. At the shallowest depths, the silt layer had been largely washed away. At 50 m the 'reef proper' began with some rock ledges and associated crevices as well as less overlying sediment.	The seabed profile was near-identical (Figure 5). Sand areas amongst rock ledges and boulders was found at the beginning of the transect (first 10 m). There was high-relief reef substrate thereafter with some mixed sand/shell/cobble in the low points. Boulder/cobble material continued until the reef gradient increased at the 50 m mark. Silt veneers were less in evidence than in 2016.
EPIBIOTIC COMMUNITIES	36 taxa recorded. A variety of sponges were present along the first 50 m of the transect after which only the grey massive sponge and yellow boring sponge (*Cliona* sp.) were present. Bryozoans (clowns hair, erect bryozoan), hydroids (feather hydroid [*Aglaophenia* sp.] and mussel beard [*Amphisbetia bispinosa*]), ascidians (saddle squirt, white colonial ascidian [*Eudistoma* sp.] and cream colonial ascidian [cf. *Didemnum* sp.]) were also present along most of the transect (0–80 m). Green-lipped mussels were occasional between 30–60 m. Conspicuous mobile fauna included gastropods (green topshell, siphon whelk, circular saw shell [*Astraea heliotropium*], white rock shell [*Dicathias orbita*], lined whelk [*Buccinulum lineum*]), kina (*Evechinus chloroticus*) and sea cucumber (*Australostichopis mollis*). Macrophyte communities were dominated by kelp (*Ecklonia* - abundant) and coralline paint (common). However, these communities were relatively diverse with a variety of other brown (*Zonaria angustata*, *Carpomitra costata*) and red (*P. cirrhosum*, *Pterocladia capillacea*) seaweeds. Kelp, flap jack (*Carpophyllum maschalocarpum*) and coralline paint were common or abundant from 60 m onwards. Tightly-packed beds of large green-lipped mussels were common from 70–100 m along the transect at depths shallower than 10 m.	43 taxa recorded. The pattern of distribution along the transect was consistent with that of 2016. Prevalance of kelp / *Ecklonia* appears unchanged. All other macroalgae also present. PR2 continues to be the only transect where *C. maschalocarpum* occurs (but restricted to shallows at end of the transect). Newly recorded algae included red encrusting algae and grass-like chorophyta but these were present at low levels only. Newly recorded sessile invertebrates (transect abundance score ≥ 3) were the orange golf ball sponge (*Tethya burtoni*) and the stony coral (*Culicea rubiola*). The only newly recorded mobile invertebrate species with a transect abundance score ≥ 3 was the Cook's turban shell (*Cookia sulcata*). No kina, *A. bispinosa, Eudistoma* sp. or *B. lineum* recorded. *Cliona* sp., and *D. orbita* less prevalent than in 2016.

	2016	2019
FISH	11 species recorded Fish were present along the full transect length with scarlet wrasse and variable triplefins the most abundant. Other fish present included butterfly perch, spotted wrasse, blue cod, dwarf scorpion fish (*Scorpaena papillosa*) and blue-eyed triplefin (*Notoclinops segmentatus*).	12 species recorded Generally the same species present but in slightly lower abundance.
NOTES	The ecological communities described above were generally similar to those at the same location in 2005 and 1991 (Duffy 1992). However, green seaweed of the genus *Caulerpa* was common in 1991 and 2005 but absent in 2016. The hydroid tree (*Solandris ericopsis*) was occasionally present in 2005 but absent in 1991 and 2016.	Good visibility (2-4 m) throughout whole transect *Caulerpa* was again absent in 2019.

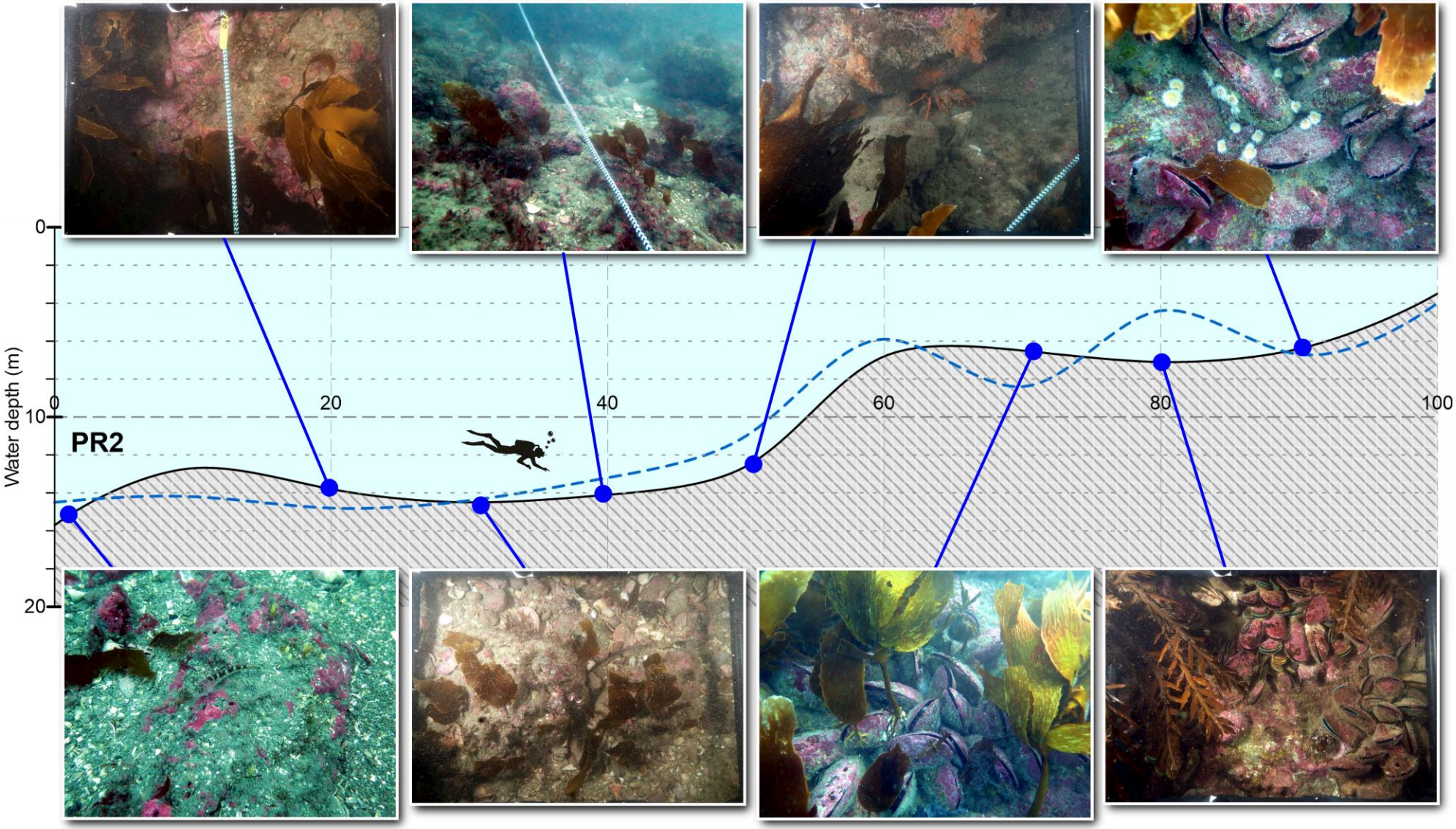

Figure 5. Depth profile with photographs of representative habitat along PR2. The photographs are aligned with the transect profile to indicate representative habitat along the transect and the blue lines indicate the location at which they were taken. Blue dashed line represents the depth profile recorded during the 2016 survey. Grey dashed line and numbers show distance along transect.

Dive Transect PR5

PR5 is situated on the eastern side of the middle section of Pania Reef and runs in a south-easterly direction. The transect profile is relatively flat, fluctuating between a water depth of 18–14.5 m, with the high point approximately 20-30 m along (Figure 6).

	2016	2019
SUBSTRATE	The substrate was dominated by bedrock covered in silt, with the occasional sandy patch halfway along the transect. The silt layer was noticeably thicker compared to that at transects PR1 and PR2.	Little free settled silt but sand areas were notably silty and embedded surface silt was a feature of encrusting communities Large stretch of sand running between 50 m and 90 m tags. Flat sand with scattered shell initially, changing to expanses of mobile rippled sand.
EPIBIOTIC COMMUNITIES	26 taxa recorded. Seafloor communites were generally consistent across the full transect length. The macroalgae community was relatively sparse, comprising red algae (*P. cirrhosum*, small bladed red algae – Rhodophyta sp.) Kelp (*Ecklonia*) was rarely encountered. Sessile epibiota communites were present, consisting mainly of grey massive (*E. alata*) and yellow tubular (*Ciocalypta* sp.) sponges, branching bryozoan, orange bryozoan (*Steginoporella* sp.) and grey colonial (c.f *Synoicum otagoensis*) and saddle squirt ascidians. Horse mussels (*Atrina zelandica*) were also encounted between 30–40 m, and green-lipped mussels at 50 m, along the transect. Mobile epifauna comprised of siphon and lined whelks (rarely encountered) and hermit crabs (common at the 30 m mark).	34 taxa recorded. The abundance record is likely compromised by the large stretches of mobile sand along the transect. However, green-lipped mussels and saddle squirts were slightly more abundant. No new algal taxa were observed but the previously occasional *P. cirrhosum* was absent. Newly recorded sessile invertebrates (transect abundance score ≥ 3) were (in order of most abundant) the orange encrusting sponge (cf.*Tedania* sp.), the lilac sponge (Demospongiae D), mussel beard (*Amphisbetia bispinosa*) and flat oysters (Ostreidae sp.). Of the previously recorded species with abundance score ≥ 3, only horse mussels were now absent. Only one occurrence of the branching bryozoan (cf. *Cellaria tenuirostris*) was noted but clowns hair bryozoan (Catenicellidae) was more prevalent than in 2016.
FISH	8 species recorded. Butterfly perch were the only fish commonly encountered although a number of other species were present including: leather jacket, red moki, blue cod, dwarf scorpion fish and variable and common triplefin.	3 species recorded. Visibility was generally not sufficient to compile a record of fish species. No triplefins were recorded.
NOTES		Very poor visibility (0.5-1 m) sometimes marginal for good data collection. Poor light penetration to the seabed, requiring artificial lighting to adequately view benthic communities.

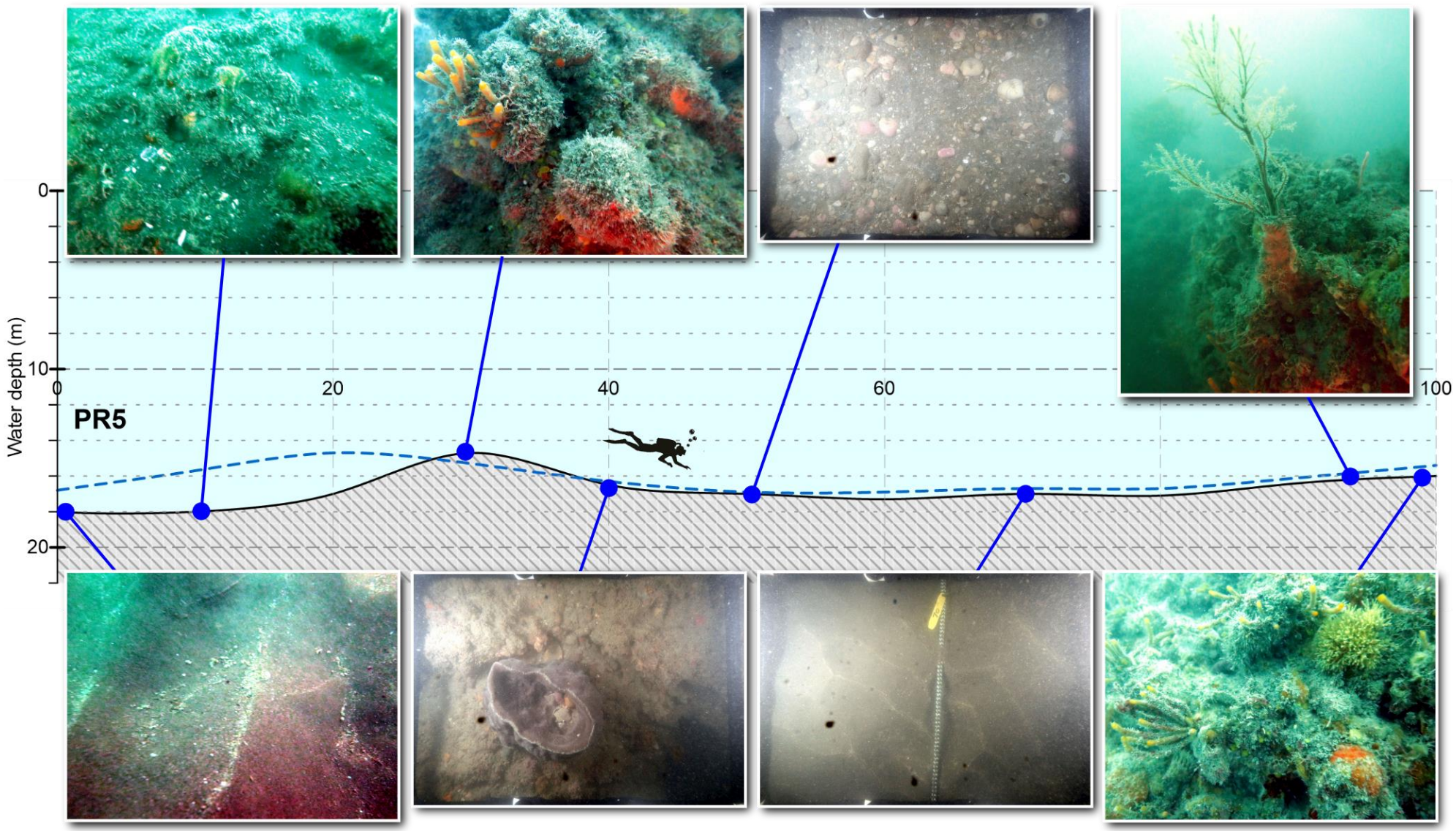

Figure 6. Depth profile with photographs of representative habitat along PR5. The photographs are aligned with the transect profile to indicate representative habitat along the transect and the blue lines indicate the location at which they were taken. Blue dashed line represents the depth profile recorded during the 2016 survey. Grey dashed line and numbers show distance along transect.

Dive transect PR3

PR3 is located on the north-west side of Pania Reef and runs in a south-easterly direction. The profile is relatively flat but varying in depth from 15 m to 9 m (Figure 7).

	2016	2019
SUBSTRATE	The seafloor substrate along the first 50 m of the transect comprised bedrock, boulders and sand patches with overlying silt in 15–13.5 m of water. From 60 m onwards the profile rose gradually and the seafloor changed to bedrock and overlying silt with the occasional patch of sand. Between 90–100 m the reef gradient rose more steeply to a depth of 8.7 m and the substrate was relatively clear of silt.	Different in profile, with the shallow point (9.5 m) at the 20 m distance mark and finishing at 15 m depth (Figure 7). Substrate alternated between abrupt high-relief outcrops and low bedrock with ledges and some boulder/cobble material. Accumulated sand and shell in pockets. Little loose settled silt though embedded silt was a feature of encrusting communities along the profile.
EPIBIOTIC COMMUNITIES	26 taxa recorded. Between 0–70 m macroalgae communities consisted largely of kelp, which was abundant, as well as red algae (*P. cirrhosum*, coralline paint). Sessile invertebrate communities included a variety of sponges (orange finger, yellow tubular, orange golf ball [*Tethya burtoni*], pink encrusting [Demospongiae sp. C], and grey massive [*E. alata*]), bryozoans (clowns hair, branching bryozoan), the feather hydroid (*Aglaophenia* sp.) and saddle squirt ascidian. Mobile epifauna included gastropods (siphon whelk, tiger shell [*Calliostoma tigris*], circular saw shell and swollen trumpet [*Argobuccinum pustulosum*]), hermit crabs and the 11-armed seastar (*Coscinasterias muricata*). After 80 m there were fewer sessile invertebrates (e.g. sponges, ascidians and bryozoans) although mussel beard hydroid, stony coral (*Culicea rubeola*) and *E. alata* were present. Epibiotic communities were instead dominated by macroalgae, mostly kelp but also coralline paint and *P. cirrhosum,* and green-lipped mussels which were common to abundant.	38 taxa recorded. The reef crest at the 20 m mark was dominated by green-lipped mussels, but otherwise, this species was less common overall. There were two newly recorded species with notable abundance scores. These were the orange erect bryozoan (*Steginoporella* sp. – score 19) and the boring sponge (*Cliona* cf. *celata* – score 17). The white colonial ascidian (*Didemnum* sp.) was also newly recorded for this transect. Nine of the new taxa were recorded from single individuals/occurences. The lilac sponge (Demospongiae D) was more prevalent than in 2016. The transect still featured abundant kelp and the prevalence of *P. cirrhosum* and coralline paint was also unchanged. No algae or invertebrates with abundance scores ≥ 3 in 2016 were now absent, but the previously occasional-to-common branching bryozoan (cf. *Cellaria tenuirostris*), was recorded from just two individual colonies. There was also a much lower incidence of feather hydroids and less mussel beard hydroid.

	2016	2019
FISH	14 species recorded. Fish encountered along the transect included: butterfly perch (*Caesioperca lepidoptera*), sweep (*Scorpis lineolata*), spotted wrasse and variable triplefin. At the start of the transect blue cod, leather jacket and dwarf scorpion fish were observed. At shallower depths (< 12 m) scarlet wrasse, red moki (*Cheilodactulus spectabilis*), banded wrasse, hiwihiwi (*Chironemus marmoratus*), marblefish (*Aplodactylus arctidens*) and oblique triplefins (*Forsterygion maryannae*) were also recorded.	8 species recorded. *Caesioperca lepidoptera* was again common to abundant along the transect. All of the six species absent from the record except the variable triplefin (*Forsterygion varium*) were observed as one or two individuals in 2016. Triplefins were notable less pravalent overall. While present, sweep and blue cod were much less abundant.
NOTES	In 2005, kelp occurred as only a sparse canopy while in 2016 it was abundant along most of the transect. Flap jack and coralline turf were also present in 2005 but absent in 2016. A number of conspicuous invertebrate taxa including sea cucumber, seastars (*Patiriella regularis*) and horse mussels were also observed in 2005 but not in 2016. Otherwise, ecological communities were generally similar between these two years.	Workable visibility (1.5-2.5 m), sufficient to observe fish. Water movement notable from video recordings.

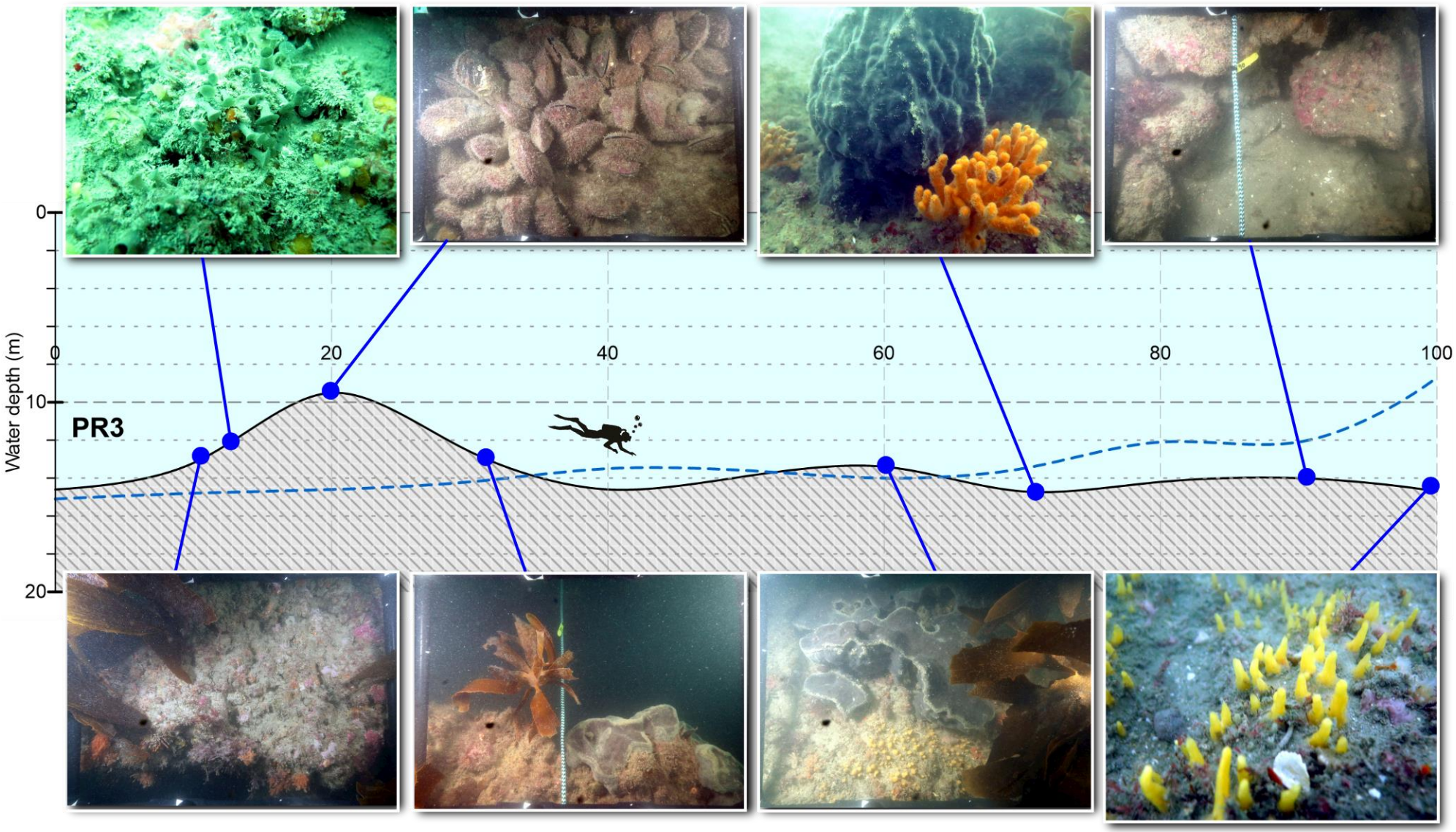

Figure 7. Depth profile with photographs of representative habitat along PR3. The photographs are aligned with the transect profile to indicate representative habitat along the transect and the blue lines indicate the location at which they were taken. Blue dashed line represents the depth profile recorded during the 2016 survey. Grey dashed line and numbers show distance along transect.

Dive Transect PR6

PR6 is situated on the north eastern side of the southern section of Pania Reef. The transect runs in a south-easterly direction and is deepest (16 m), and flattest in profile, for the first 50 m (Figure 8). After this it rises sharply to its shallowest depth of 10 m at the 70-80 m distance marks before descending again to approximately 14 m depth at the end.

	2016	2019
SUBSTRATE	The substrate was dominated by bedrock, which was covered in sandy patches and silt along the first half and near the end of the transect. Noticeably less silt covered the substrate between 60–70 m when the profile was at its shallowest.	There was good agreement between transect profile records (Figure 8). Low bedrock with occasional ledges was dominant for first 70 m then a large vertical outcrop. Some sand in small pockets and niches only. Entrapped/embedded silt was a feature of encrusting communities.
EPIBIOTIC COMMUNITIES	30 taxa recorded. Between 0–40 m along the transect macroalgal communities were sparse and restricted to red algae (*P. cirrhosum* and coralline paint). Sessile invetebrate communities comprising sponges, bryozoans, hydroids and ascidians were present, with taxa including: grey massive sponge (*E. alata*), yellow lumpy sponge (Demospongiae sp. E), grey lobed sponge (c.f *Thorecta* sp.), erect brancing and orange bryozoans, branching hydroids, saddle squirt and grey and white colonial ascidians. Mobile invertebrates, present in small numbers, included siphon whelk (*Penion sulcatus*), hermit crabs and sea cucumbers. Between 70–80 m some sessile biota were less prevalent although these were again encountered at the 90–100 m mark. The only mobile taxon observed after 40 m was a butterfly chiton (*Cryptochonchus porosus*). Kelp was present only after 50 m and was common from 70 m onwards. Red algae (*P. cirrhosum* and coralline paint) were also present.	46 taxa recorded. As in 2016, kelp / *Ecklonia* was present only after 50 m at similar low abundance. The small-blade red alga was newly recorded in 2019 (transect abundance score 11) although archived photos show that this relatively inconspicuous alga was overlooked by divers in 2016. *E. alata* was a dominant presence in the first 50 m, with *R. topsenti* also persistently occasional. There was a dense bed of green-lipped mussels on an outcrop at the 70 m mark. Newly recorded sessile invertebrates (transect abundance score ≥ 3) were the boring sponge (*Cliona* cf. *celata*), the globose sponge (*Aaptos globosum* – possibly misidentified earlier as *Tethya bergquistae*), the soft coral (*Alcyonium* cf. *aurantiacum*) stony coral (*Culicea rubiola*) and white *Didemnum* sp. Prominent zoanthid colony beneath outcrop. The grey lobed sponge (cf. *Thorecta* sp.), occasional in 2016, was not observed and the orange encrusting sponge (cf.*Tedania* sp.) was notably less prevalent, as were the yellow Demospongiae E, the branching bryozoan (cf. *Cellaria tenuirostris*) and branching hydroid. Of mobile invertebrates, the top shell (*Calliostoma tigris*), clown nudibranch (*Ceratosoma amoena*) and kina were newly recorded with transect abundance scores of 3, 4 and 3, respectively.

	2016	2019
FISH	13 species recorded. A variety of fish were encountered including: butterfly perch, blue cod, leather jacket, red moki, spotted wrasse, tarakihi (*Nemadactylus macropterus*), sweep, dwarf scorpion fish, banded wrasse, variable triplefin, spectacled triplefin (*Ruanoho whero*) and scarlet wrasse.	10 species recorded. Unusually, no variable triplefin (*Forsterygion varium*) were observed along the transect. Spotted wrasse (*Notolabrus celidotus*) were also present only in low numbers.
NOTES		Good visibility (2.0–2.5 m) but suspended particulate matter was notable from video.

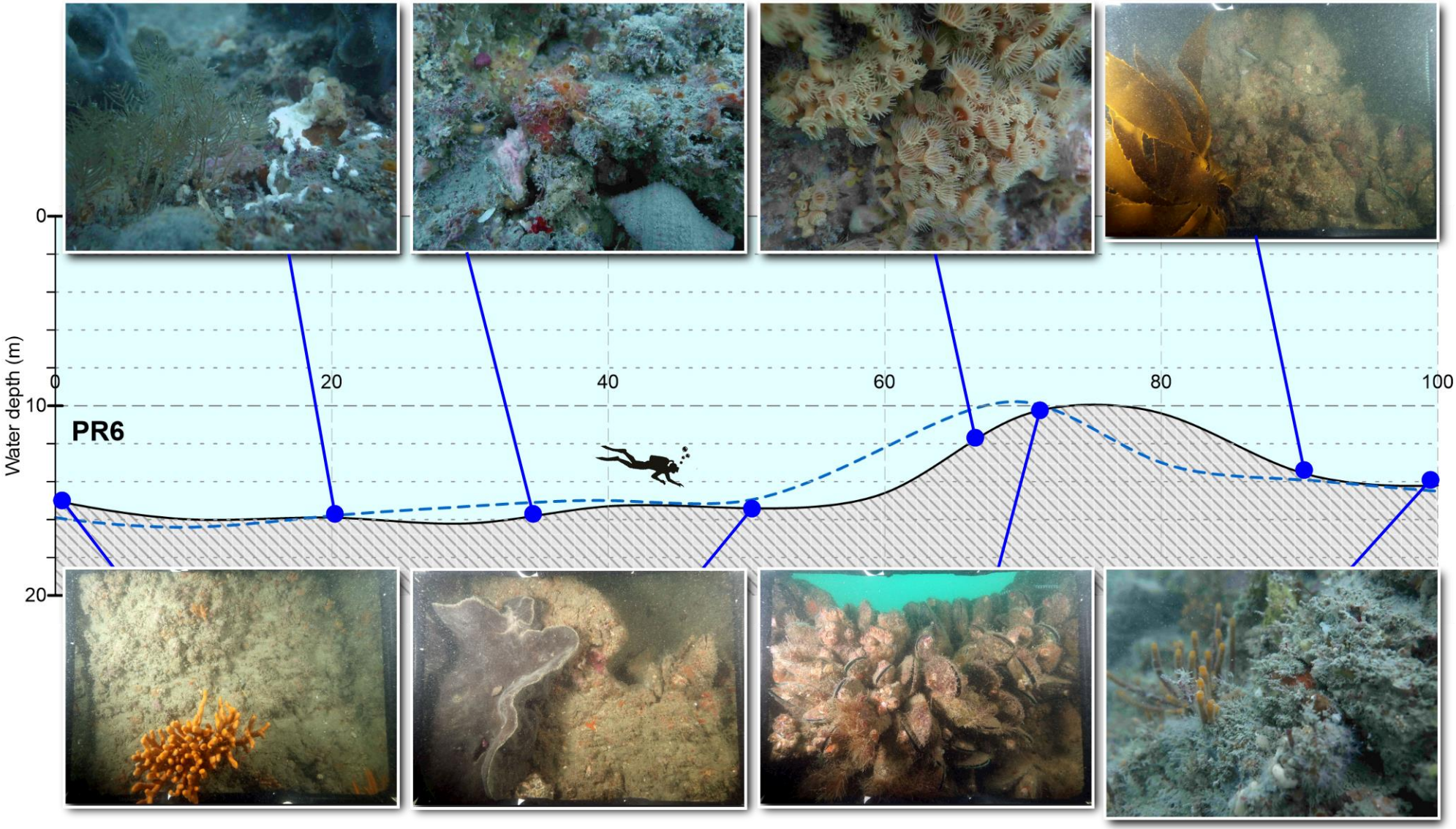

Figure 8. Depth profile with photographs of representative habitat along PR6. The photographs are aligned with the transect profile to indicate representative habitat along the transect and the blue lines indicate the location at which they were taken. Blue dashed line represents the depth profile recorded during the 2016 survey. Grey dashed line and numbers show distance along transect.

Dive Transect PR4

PR4 is located on the north-westerly side of the most southern section of Pania Reef and runs in a south–easterly direction. The transect profile is relatively flat, fluctuating between 13–10 m water depth (Figure 9).

	2016	2019
SUBSTRATE	The substrate along most of the transect comprised bedrock, except for between 70–90 m where cobble and sand overlaid the bedrock. Silt was prevalent along the full transect length.	Low uneven bedrock throughout. Coarse silty sand only in small pockets at low points. Silt consistently embedded in encrusting communities. Fine dusting of silt covering reef surfaces and biota.
EPIBIOTIC COMMUNITIES	32 taxa recorded. Seafloor communities were relatively consistent along the transect and included sponge gardens comprising a variety of sessile biota. The most common of these were sponges (*E. alata*, *R. topsenti*, *Ciocalypta* sp. and *T. burtoni*), bryozoans (clowns hair, erect), the feather hydroid (*Aglaophenia* sp.) and ascidians (saddle squirt, white colonial ascidian and white *Didemnum*). Macroalgae included kelp / *Ecklonia* (occasional to common) as well as red algae (*P. cirrhosum*, small-blade alga and coralline paint). Mobile epifauna included gastropods (*P. sulcatus*, *Trochus viridus* and *Caliostoma cunninghami*), hermit crabs and sea cucumbers. Green-lipped mussels were occasionally encountered in the final 10 m of the transect.	36 taxa recorded. Kelp / *Ecklonia* was occasional to common along transect length, abundant in the last 10 m. Small-blade red alga was much less prevalent than in 2016. There was a decrease also in *P. cirrhosum* and coralline algae. Dense green-lipped mussels on a reef crest at the 50 m mark. Newly recorded sessile invertebrates (transect abundance score ≥3) were the fan bryozoan (cf. *Caberea zelandica*), mussel beard (*A. bispinosa*), red-mouthed ascidian (Ascidiacea sp. A) and clown nudibranch (*C. amoena*). Of the previously recorded species with abundance score ≥ 3, those not observed in 2019 were saddle squirts (*Cnemidocarpa* sp.) and branching bryozoan (cf. *Cellaria tenuirostris*). It is possible that the former was present as it was observed elsewhere on the reef and can be difficult to discern in silty conditions.
FISH	8 species recorded. Fish communities comprised butterfly perch, spotted wrasse, blue cod, dwarf scorpion fish, variable triplefin, leather jacket, scarlet wrasse. An eagle ray (*Myliobatis tenuicaudatus*) was also observed.	3 species recorded (as single individuals). Visibility was insufficient to assess the occurrence of fish.

	2016	2019
NOTES	In 2005, a bed of well-established green-lipped mussels encrusted the entire top of a large boulder at the shallow end (≤ 10 m depth) of the transect. Clusters of stalked ascidians (*Pyura* sp.) colonised the boulder and *C. maschalocarpum* was also present. The 2016 transect profile was deeper than 10 m, which likely explains why mussels were only occasionally encountered and flap jack was absent.	Poor visibility (0.5–1.0 m). Little could be discerned from recorded video.

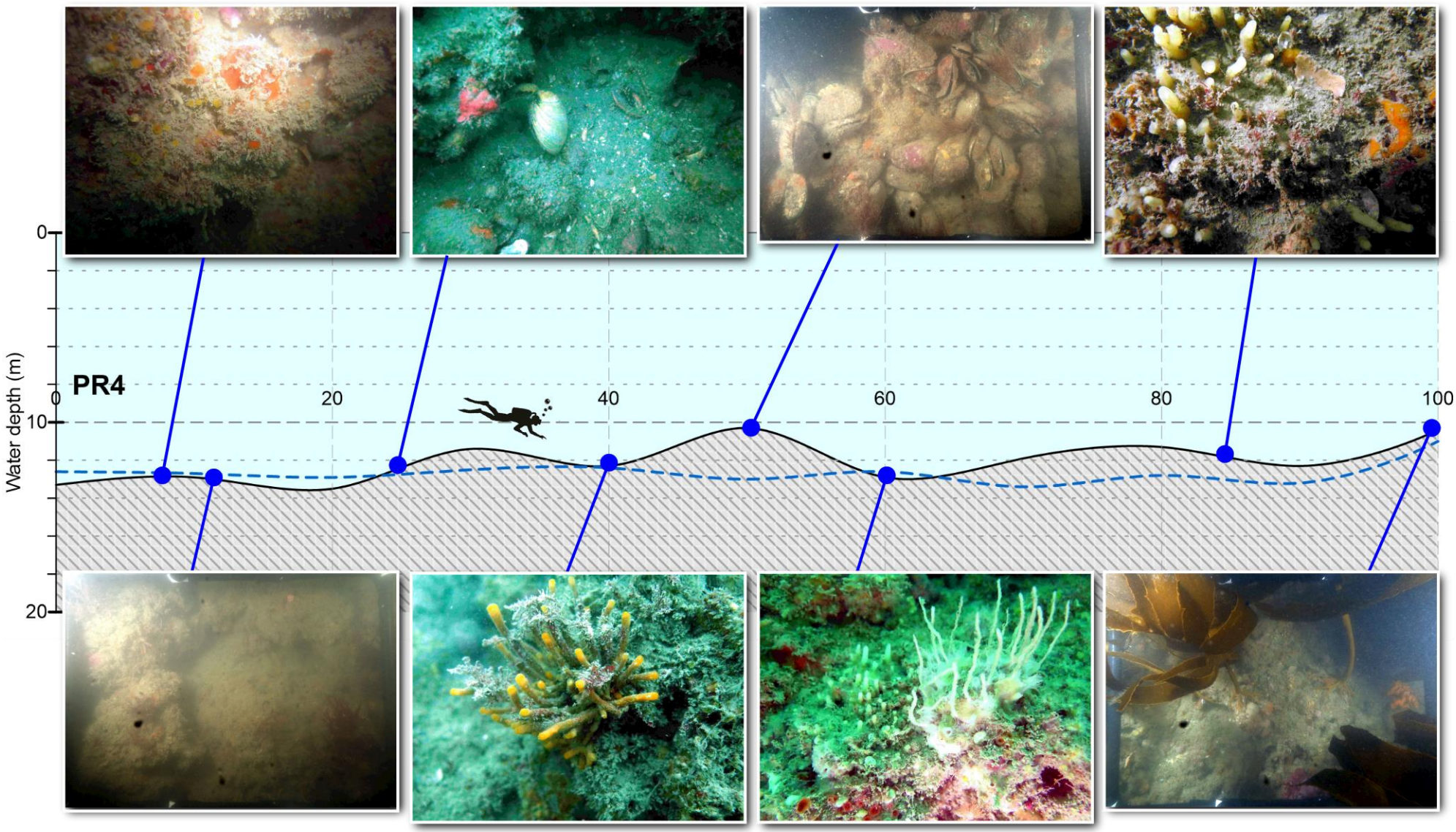

Figure 9. Depth profile with photographs of representative habitat along PR4. The photographs are aligned with the transect profile to indicate representative habitat along the transect and the blue lines indicate the location at which they were taken. Blue dashed line represents the depth profile recorded during the 2016 survey. Grey dashed line and numbers show distance along transect.

Dive Transect PR7

PR7 is located on the north-eastern side of Pania Reef and runs in a south-easterly direction. The transect profile is undulating but rises gently from 16 m water depth to 11 m depth at the end (Figure 10).

	2016	2019
SUBSTRATE	The substrate was dominated by bedrock overlaid with a heavy covering of silt, and the occasional patch of sand in the middle of the transect. Silt was less prevalent from 90 m onwards where the transect was slightly shallower.	Mobile sand substrate was prevalent in the first 30 m of the transect, although the bedrock of the reef emerged in places. From there, low uneven bedrock with ledges, holes and fissures. Expanses of highly textured though horizontal reef surface served to entrap significant amounts of sediment in even the smallest pockets and niches. High levels of embedded/entrapped silt in encrusting communities.
EPIBIOTIC COMMUNITIES	29 taxa recorded. Macroalgal communities along the full transect length included red algae (*P. cirrhosum* and small blade red), both of which were sparse. From 10 m onwards, kelp / *Ecklonia* was also occasionally or commonly present. Sessile biota communities along most of the transect included sponges (*E, alata*, *Tethya bergquistae*, *Ciocalypta* sp., *R. topsenti*, lilac Demospongiae sp. D, and yellow lumpy Demospongiae sp. E), bryozoans (clowns hair, brancing [cf. *Cellaria tenuirostris*] and *Steginoporella* sp.), feather hydroids (cf. *Aglaophenia* sp.), cnidarians (*Anthothoe albocincta*, *Alcyonium* cf. *aurantiacum*) and ascidians (*Cnemidocarpa* sp. and *Eudistoma* sp.). Flat oysters (Ostreidae sp.) were observed between 10–30 m. From 90 m onwards, a reduced variety of sessile invertebrates were observed including: sponges (*E. alata*, *Ciocalypta* sp., lilac Demospongiae sp. D and *T. bergquistae*), bushy hydroids and grey colonial ascidians (cf. *Synoicum otagoensis*). Green-lipped mussels were present from 50 m, and common from 70 m, onwards. Conspicuous mobie epifauna along the transect included: *P. sulcatus, B. lineum, C. tigris* as well as hermit crabs, sea cucumber (*A. mollis*) and the 11-armed seastar (*C. muricata*).	47 taxa recorded. There was lower incidence of all previously recorded algal species (*Ecklonia, P. cirrhosum* and small-blade red algae). However, a very small amount of coralline algae was observed. Newly recorded sessile invertebrates (transect abundance score ≥ 3) were encrusting and fan bryozoans, sponges (*T. burtoni*, orange encrusting cf.*Tedania* sp., globose cf. *A. globosum*), stalked ascidians (*Pyura spinosissima*), red-mouthed ascidian (Ascidiacea sp. A) and a cream colonial ascidian (*Didemnum* sp.). Of the previously recorded species with abundance score ≥ 3, only the tiger top-shell (*C. tigris*) was absent from the transect. However, there was less of the lilac Demospongiae D, lobed grey sponge (cf. *Thorecta* sp.) and the ascidians *Cnemidocarpa* sp. and cf. *Synoicum otagoensis*. There was significantly less of the branching bryozoan (cf. *Cellaria tenuirostris*) and feather hydroid (cf. *Aglaophenia* sp.). Although present, green-lipped mussels were also less abundant.

	2016	2019
FISH	7 species recorded. A variety of fish were encountered with butterfly perch (*C. lepidoptera*) and blue cod (*P. colias*) the most common. Variable triplefin, banded triplefin (*F. malcomi*), scarlet wrasse (*P. miles*) and dwarf scorpion fish (*Scorpaena papillosa*) were also present.	6 species recorded. Visibility was not generally sufficient to adequately record fish species.
NOTES		Poor visibility (0.5–1 m) and poor light penetration to the seabed (artificial light required to document encrusting communities). Data may suffer from a rarefaction effect whereby a constrained field of view restricts what may actually be ‘occasional’ (O), resulting in more taxa being encoded ‘rare’ (R).

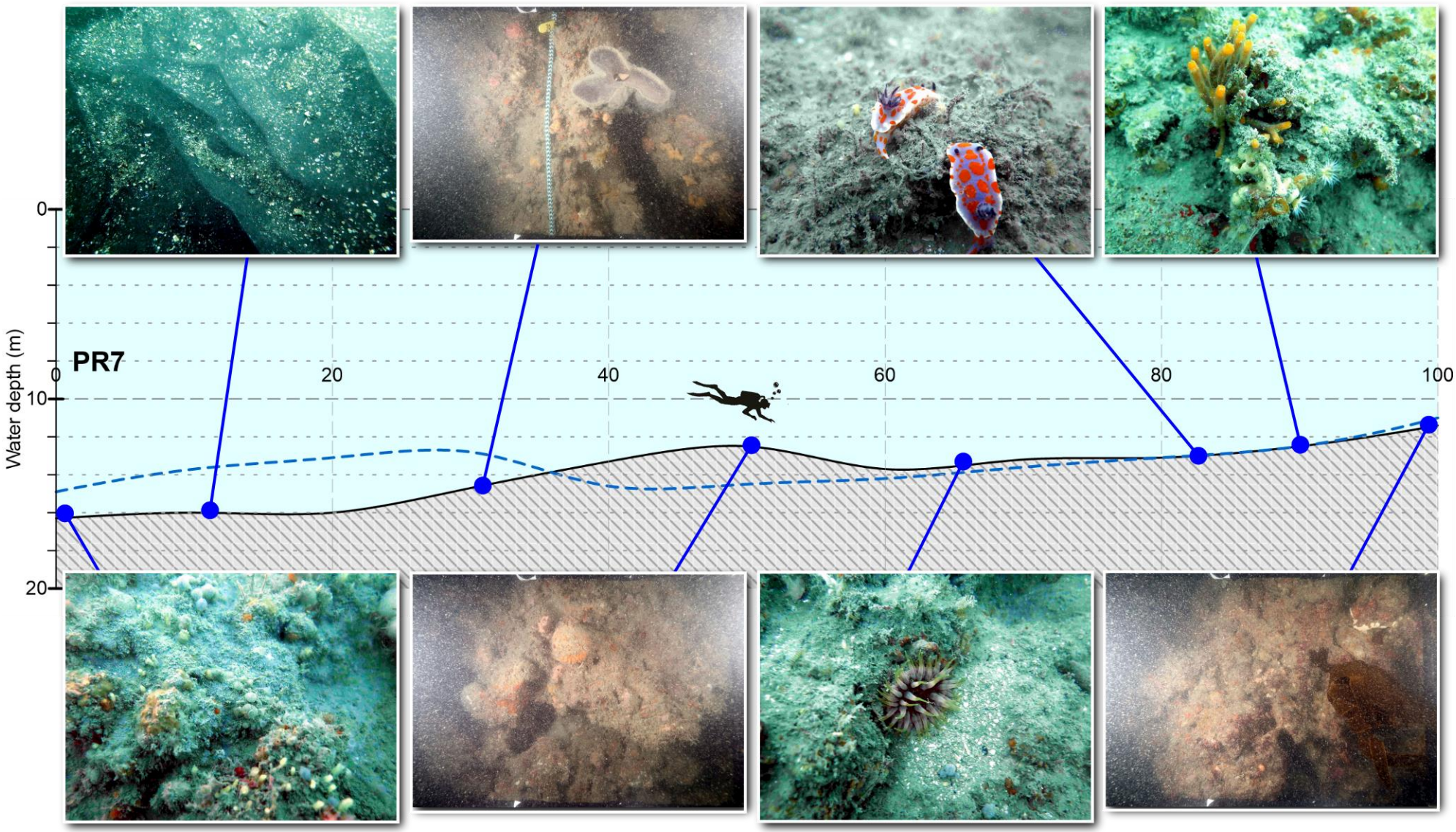

Figure 10. Depth profile with photographs of representative habitat along PR7. The photographs are aligned with the transect profile to indicate representative habitat along the transect and the blue lines indicate the location at which they were taken. Blue dashed line represents the depth profile recorded during the 2016 survey. Grey dashed line and numbers show distance along transect.

Dive Transect PR8

PR8 is the southernmost transect (closest to the shore) on Pania Reef and runs in a south-easterly direction. The transect profile begins at 16 m depth and, from around the 20 m mark rises to 12 m depth after which it is relatively flat, fluctuating between 13–11 m depth (Figure 11).

	2016	2019
SUBSTRATE	Along the first 10 m, the substrate was dominated by silty sand after which silt-covered bedrock (with sand at 70 m) became abundant. Silt layers were relatively thick along the full transect length.	Low uneven bedrock was found throughout the transect. Comparison of the profiles suggests that 2019 transect missed the initial sand substrate. Seabed terrain was similar to that of PR7. Patches of embedded boulders. Occasional larger boulders and outcrops. Surface silt layer easily disturbed.
EPIBIOTIC COMMUNITIES	37 taxa recorded. No conspicuous biota were encountered in the sandy habitat at the start of the transect. After 10 m, macroalgal communities, restricted to red algae (*P. cirrhosum* and coralline paint) and small red bladed algae (from 60 m onwards), were present. Diverse communities of sessile biota were present, with the most common being sponges (*E. alata*, *T. burtoni*, *Ciocalypta* sp., *R. topsenti*, lilac Demospongiae D, yellow Demospongiae E, orange encrusting [cf.*Tedania* sp.]), feather hydroids, orange bryozoan (*Steginoporella*), white striped anemone (*A. albocincta*) and ascidians (*Pyura, Cnemidocarpa*, cf. *Synoicum otagoensis*, *Eudistoma* sp. and cream and white colonial [*Didemnum*]). The hydroid tree (*Solandris ericopsis*) was also encountered. Horse mussels and oysters were present between 10–20 m and green-lipped mussels encountered at the 50 m mark. A range of mobile invertebrates occurred in low numbers including *P. sulcatus*, *C. cunninghami*, *C. puntulatum,* clown nudibranch (*Ceratosoma amoena*), sea cucumber (*A. mollis*) and hermit crabs. Spiny rock lobster (*Jasus edwardsii,* were present between the 40–50 m marks.	46 taxa recorded. As in 2016, no kelp / *Ecklonia* was observed along the transect*. P. cirrhosum* and small-blade red alga were the only macroalgae redorded, although both were lower in occurrence than in 2016. The most conspicuous sessile species was *E. alata* which was occasional to common. Newly recorded sessile invertebrates (transect abundance score ≥ 3) were small red-mouthed ascidians (Ascidiacea sp. A), branching hydroids, the branching sponge (cf. *Iophon minor*), boring sponge (*Cliona* cf. *celata*), a red emergent/encrusting sponge (cf. *Stylopus australis*) and an identified orange sponge with an an apparent honeycomb structure. Feather hydroids, the bryozoan *Steginoporella* and the white *Didemnum* colonial ascidian were more abundant than in 2016. Of the previously recorded species with abundance score ≥ 3, only the pink golf ball sponge (*Tethya bergquistae*) was not observed in 2019. *Pyura* was less abundant with only a single incidence recorded.

	2016	2019
FISH	6 species recorded. Butterfly perch and blue cod were the most common fish observed along the transect. Spotted wrasse, variable triplefin, scarlet wrasse and blue moki (*Latridopsis ciliaris*) were also present.	6 species recorded. Lower fish occurrence generally than in 2016. Banded wrasse (*Notolabrus fucicola*) and spectacled triplefin (*Ruanoho whero*) were observed but not scarlet wrasse or blue moki.
NOTES		Limited visibility (1 m) and poor light penetration to the seabed (artificial light required to document encrusting communities).

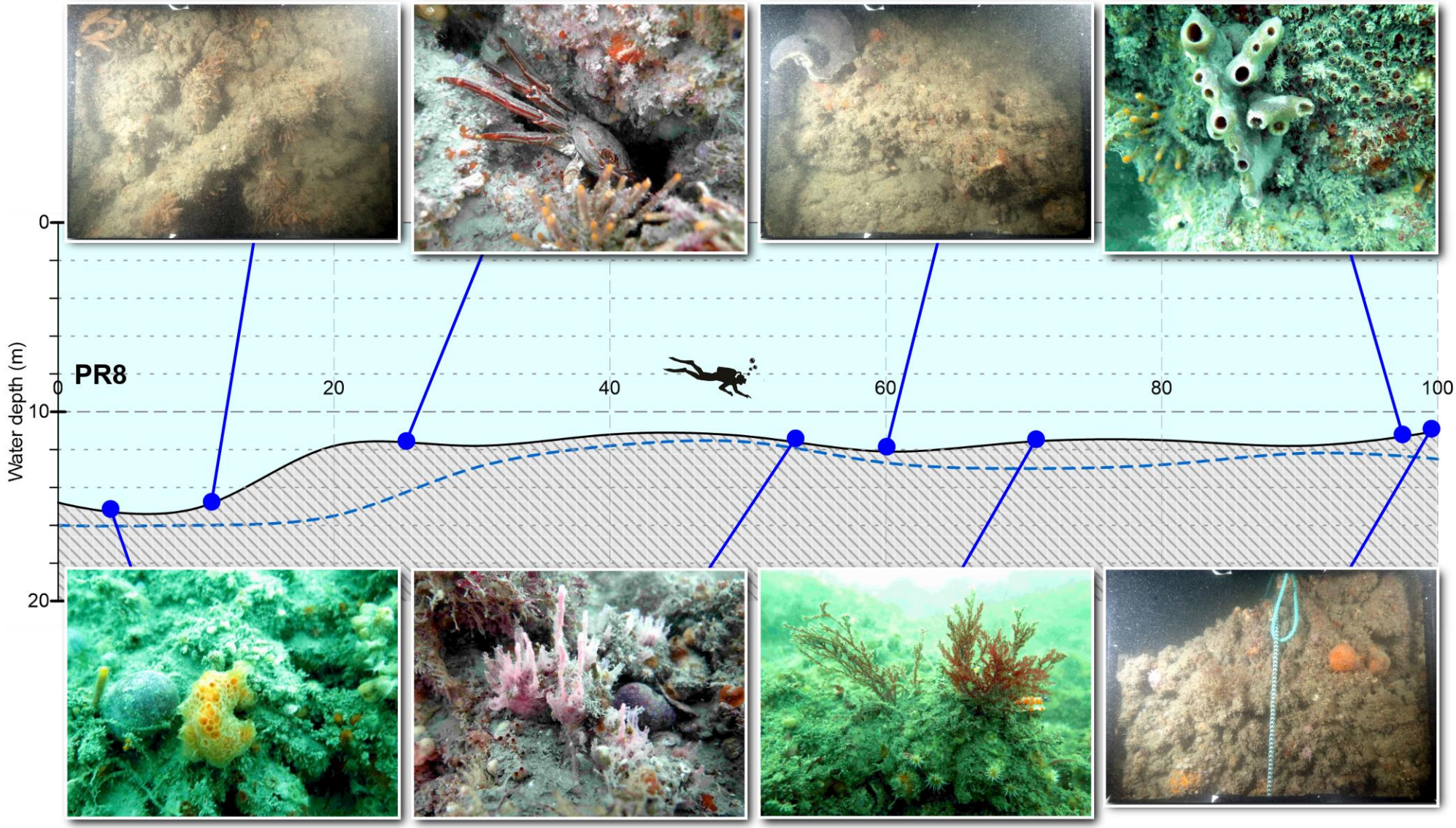

Figure 11. Depth profile with photographs of representative habitat along PR8. The photographs are aligned with the transect profile to indicate representative habitat along the transect and the blue lines indicate the location at which they were taken. Blue dashed line represents the depth profile recorded during the 2016 survey. Grey dashed line and numbers show distance along transect.

3.1.3. Substrate

Like the record of depth profile, the prevalence of different substrates recorded by divers was mostly a check on transect placement to ensure that comparisons between surveys were not confounded by markedly different habitats. Except for transect PR5, the scores for the four substrate categories (bedrock, boulder, cobble, sand[3]) were comparable between the two surveys.

At PR5, a decrease in bedrock prevalence was balanced by an increase in sand. Examination of the transect record for PR5 shows that sand was the sole substrate for the first ten metres of the transect and for the section from 50 to 80 m. These stretches also recorded a corresponding paucity of sessile biota. This, together with conspicuous sand ripples (photographs Figure 6) indicated that this sediment substrate was mobile. The record from the 2016 survey shows sand as consistently 'occasional' only in the section from 50 m to 80 m. The flat and low-lying nature of this part of the transect suggests that sand inundation may be a regular feature. Since such a change can significantly affect the communities supported, it needs to be considered when assessing the ecological data.

Notably, there was no general increase in the prevalence of sand across transects. Most transects recorded slightly less sand compared to the 2016 record. The only transect other than PR5 that recorded a (small) increase in sand was PR7 and this all occurred in the first 30 m. A comparison of the transect profile between surveys indicates that this section was more low-lying in 2016 (Figure 10), suggesting a material change in transect placement may have been at least partly responsible.

3.1.4. Inventory and occurrence of taxa

A list of the conspicuous epibiota[4] recorded for each transect are presented in Table 2, along with the range of abundance categories recorded. To assist with interpretation of the condensed data, the table cell for each taxon is shaded according to the total score for the transect from summation of the rank quantifications of abundance for each 10 m segment. In this way, the variability across transects for each taxon can be better visualised. The transect abundance scores for individual taxa upon which shading is based (generated according to categorisations in Table 1) are listed in Appendix 2.

[3] It should be noted that silt is not included because the hydrodynamics of the reef prevent it from occurring as a substrate. While the presence of settled silt veneers is recorded in diver observations where it occurs, this does not constitute a substrate.

[4] The accurate identification of many encrusting taxa from a photographic record is challenging, and for certain groups (e.g. sponges) the range of image-based taxonomic references available is limited. Hence many of the identifications are tentative or descriptive. But because a comprehensive image library for the surveys has been compiled, this indeterminate status does not prevent a subsequent assessment of the nature and scale of change in these communities.

Table 2. Epibiota taxa list and the range of abundance rankings along the eight transects surveyed on Pania Reef in May 2019. N = not present, R = rare, O = occasional, C = common, A = abundant. A blank cell indicates complete absence all along the transect (i.e. N). Green shading is progressive, based on the total abundance score for the transect for each taxon (Section 2.1.1). Yellow cells indicate taxa not recorded in 2016. Transects are listed in the order of increasing distance from the seaward end of the reef (north to south).

Taxon	**Common name / descr.**	**PR1**	**PR2**	**PR5**	**PR3**	**PR6**	**PR4**	**PR7**	**PR8**
Phaeophyceae	**Brown algae**								
Ecklonia radiata	Kelp	N-A	R-A	N-R	O-A	N-C	O-A	N-O	
Carpophyllum maschalocarpum	Flap jack		N-A						
Halopteris sp.		N-R	N-C						
Zonaria sp.			N-O						
Carpomitra costata		N-R	N-C						
Rhodophyta	**Red algae**								
Corallinales	Coralline paint	N-C	C-A		O-C	N-O	N-O	N-R	
Plocamium cirrhosum		N-O	N-C		N-C	N-O	R-O	N-O	N-O
Pterocladia capillacea			N-O						
Rhodophyta sp.	Small red blade algae		N-R		N-R	N-C	N-O	N-R	N-O
Red encrusting algae			N-O						
Chlorophyta	**Green algae**								
Chlorophyta	Green algae (grass-like)		N-O						
Porifera	**Sponges**								
Ecionemia alata	Grey vase sponge	N-C	N-A	N-C	O-C	N-C	O-C	N-O	N-C
Cliona cf. *celata*	Yellow boring sponge	N-C	N-C		N-C	N-O	N-O		N-O
Red cf. Stylopus australis	Red encrusting sponge								N-O
Orange cf. *Tedania* sp.	Orange encrusting sp.	N-O	N-O	N-C	N-R	N-O	N-O	N-O	N-O
Orange cf. *Hymeniacidon* sp.	Orange massive sponge		N-O						N-R
Tethya bergquistae	Pink golf ball sponge	N-R		N-R	N-R	N-A	N-R	N-O	
Tethya burtoni	Orange golf ball sponge	N-R	N-R	N-R	N-R	N-O	N-O	N-R	N-O
Ciocalypta sp.	Yellow tubular sponge	N-C	N-O	N-O	N-C	N-O	N-O	N-C	N-C
Lobed grey cf. *Thorecta* sp.	Lobed grey sponge	N-R						N-R	N-R
Raspalia topsenti	Orange finger sponge	N-O	N-O	N-O	N-O	N-C	N-O	N-O	N-O
White/green Demospongiae A	White/green massive sp.			N-R		N-R			N-R
Grey Demospongiae B	Grey lumpy massive sp.		N-R		N-O			N-R	
Pink Demospongiae C	Pink thick encrusting sp.		N-R		N-O			N-R	
Lilac Demospongiae D	Lilac spiky sponge	N-O		N-O	N-O	N-O	N-O	N-O	N-C
Yellow Demospongiae E	Yellow lumpy massive sp.			N-R	N-R	N-O		N-O	N-O
Maroon Demospongiae F	Maroon massive sponge	N-R		N-R		N-R			
Latrunculia cf. *procumbens*	Green encrusting sp.		N-O			N-R	N-R	N-R	
Grey cf. *Ircinia novaezealandiae*	Grey encrusting sponge		N-R						
Brown cf. *Polymastia massalis*	Brown massive sponge							N-R	N-R
Globose cf. *Aaptos globosa*	Globose sponge			N-R		N-R	N-R	N-R	
Branching cf. *Iophon minor*	Cream branching sp.								N-C

Taxon	Common name / descr.	PR1	PR2	PR5	PR3	PR6	PR4	PR7	PR8
Orange honeycomb sponge									N-R
cf. *Dendrilla rosea*	Pink erect conulose		N-R	N-R		N-R			
Bryozoa	**Bryozoans**								
Bryozoan Catenicellidae	Clowns hair/moss bryoz.	N-C	N-C	N-O	N-C	N-O	N-O	N-R	N-O
Branching cf. *Cellaria tenuirostris*	Branching erect bryoz.	N-C		N-R	N-O	N-O		N-C	N-R
Fan cf. *Caberea zelandica*	Erect fan bryozoan			N-R		N-O	N-R	N-R	N-R
Orange cf. *Steginoporella* sp.	Orange tube bryozoan	N-C		N-C	N-C	N-C	N-O	N-O	N-C
Encrusting bryozoan		N-C						N-C	N-R
Erect cf. *Margaretta barbata*	Bryozoan		N-R						N-R
Cnidaria	**Hydroids, anemones, corals**								
Feather cf. *Aglaophenia* sp.	Feather hydroid	N-R	N-R		N-O	N-R	N-O	N-O	N-O
Solanderia ericopsis	Hydroid tree			N-R		N-R	N-R		
Amphisbetia bispinosa	Mussel beard hydroid	N-O		N-O	N-C	N-O	N-C		
Branching / bushy hydroid	Bushy hydroid			N-O		N-R	N-O	N-C	N-O
Anthothoe albocincta	White-striped anemone	N-R	N-C				N-R	N-O	N-C
Solitary anemone Undescr.		N-O						N-R	
Alcyonium cf. *aurantiacum*	Common soft coral			N-R		N-O		N-O	N-O
Culicia rubeola	Colonial stony coral	N-O	N-C	N-R	N-C	N-O	N-O	N-R	N-R
Corynactis australis	Jewel anemone		N-R			N-R			
Parazoanthus elongatus	Zoanthid anemone			N-R		N-R			
Fine hydroid						N-R			
Ascidiacea	**Tunicates, sea squirts**								
Pyura spinosissima	Sea tulip	N-R					N-R	N-C	N-R
Cnemidocarpa sp.	Saddle squirt	N-O	N-R	N-C	N-O	N-O		N-C	N-O
Ascidiacea sp. A	Small red-mouthed asc.		N-C	N-O		N-C	N-C	N-C	N-C
Cf. *Synoicum otagoensis*	Grey colonial ascidian	N-R		N-O		N-R	N-R	N-C	N-C
Eudistoma sp.	White colonial ascidian	N-R		N-R		N-R	N-R	N-O	N-O
Cream asc. cf. *Didemnum*	Cream colonial ascidian						N-R	N-O	N-R
Didemnum (white)	White didemnum				N-O	N-C	N-O	N-R	N-C
Bivalvia	**Clams**								
Perna canaliculus	Green-lipped mussel	N-C	N-A	N-C	N-A	N-A	N-A	N-R	
Ostreidae sp.	Flat oyster	N-R		N-C	N-R		N-R	N-O	N-R
Bivalve (embedded unid)	Boring bivalve	N-R	N-R	N-R				N-R	
Polyplacophora	**Chitons**								
Cryptoconchus porosus	Butterfly chiton				N-R		N-R		
Gastropoda	**Snails, sea slugs**								
Trochus viridus	Green top shell	N-O	N-O		N-R	N-O	N-R		N-R
Calliostoma tigris	Tiger shell				N-R	N-R			
Calliostoma pellucida forsteriana	Top shell			N-R					
Calliostoma punctulatum	Beaded top shell				N-R	N-R			N-R

Taxon	Common name / descr.	PR1	PR2	PR5	PR3	PR6	PR4	PR7	PR8
Cookia sulcata	Cook's turban shell	N-R	N-R		N-R				
Astraea heliotropium	Circular saw shell				N-R				
Argobuccinum pustulosum	Swollen trumpet shell					N-R	N-O		
Dicathais orbita	White rock shell	N-O	N-R		N-R				
Buccinulum linea	Lined whelk								N-R
Penion sulcatus	Siphon whelk	N-R	N-R		N-O	N-O	N-R	N-R	N-R
Cominella adspersa	Speckled whelk	N-R							
Whelk (Muricidea unid)	Unid. whelk	N-R							
Cabestana spengleri	Spengler's trumpet		N-R						
Ceratosoma amoenum	Clown nudibranch	N-O	N-R	N-R	N-R	N-O	N-R	N-R	N-O
Crustacea	**Crabs, lobster, barnacles**								
Jasus edwardsii	Crayfish		N-R					N-O	N-R
Paguridae	Hermit crab		N-R	N-R	N-O	N-R		N-R	N-O
Guinusia chabrus	Red rock crab								N-R
Barnacle unid.	Barnacle				N-R			N-R	
Echinodermata	**Sea cucumbers, seastars, urchins**								
Australostichopus mollis	Sea cucumber	N-R	N-R		N-R	N-R		N-O	N-R
Patiriella regularis	Cushion star							N-R	
Astrostole scabra	7-armed seastar		N-R		N-R			N-R	N-R
Ophiopsammus sp.	Snake star			N-R					
Evechinus chloroticus	Kina					N-O			
Osteichthyes	**Fish**								
Parika scaber	Leather jacket	N-O	N-R		N-R			N-R	
Caesioperca lepidoptera	Butterfly perch	N-O	N-C	N-R	N-C	N-C	N-R	N-R	N-C
Cheilodactylus spectabilis	Red moki		N-R		N-R	N-R			
Notolabrus celidotus	Spotted wrasse	N-R	N-R		N-O			N-R	N-O
Nemadactylus macropterus	Tarakihi					N-R			
Parapercis colias	Blue cod	N-O	N-R	N-O	N-R	N-R	N-R	N-O	N-O
Scorpis lineolatus	Sweep		N-C		N-O	N-C			
Scorpaena papillosa	Dwarf scorpion fish	N-R	N-O		N-R	N-R	N-R		
Notolabrus fucicola	Banded wrasse		N-R			N-R			N-R
Pseudolabrus miles	Scarlet wrasse	N-R	N-O	N-R	N-O	N-R		N-R	
Latridopsis ciliaris	Blue moki		N-R						
Hypoplectrodes huntii	Banded perch					N-R			
Forsterygion varium	Variable triplefin	N-R	N-R					N-R	N-R
Ruanoho whero	Spectacled triplefin								N-R
Forsterygion malcolmi	Banded triplefin		N-R			N-R			

Spatial gradients in occurrence

A number of taxa exhibited spatial gradients in their occurrence along the reef axis. These gradients are indicated by those that show progressive shading across transects in Table 2. Taxa for which increasing prevalence from north to south was indicated included the following:

- Sponges
  - Lilac Demospongiae D
  - Branching sponge (cf. *Iophon minor*)
  - Grey lobed sponge (cf. *Thorecta* sp.)
  - *Tethya* (both *bergquistae* and *burtoni*)
  - Yellow Demospongiae E
- Ascidians
  - Saddle squirt (*Cnemidocarpa* sp.)
  - Small red-mouthed ascidian (Ascidiacea sp. A)
  - White colonial ascidian (cf. *Synoicum otagoensis*)
  - Grey colonial ascidian (cf. *Eudistoma* sp.)
  - *Didemnum* sp.
- Cnidarians
  - Feather and branching hydroids
  - White striped anemone (*Anthothoe albocincta*)
  - Soft coral (*Alcyonium* cf. *aurantiacum*)

Taxa for which decreasing prevalence from north to south was indicated included:

- Algae
  - Kelp (*Ecklonia radiata*)
  - Coralline paint
- Bryozoans
  - Clowns hair bryozoan (Catenicellidae)
  - Orange erect bryozoan (cf. *Steginoporella* sp.)
- Green-lipped mussels (*Perna canaliculus*)

There are likely to be several interrelated factors driving these gradients. Physical gradients along the reef include turbidity, depth and topography. Overall, the outer sections of the reef are likely to experience lower turbidity due to lower exposure to wave resuspension processes operating in shallower water depths nearer the shore. This, in turn, results in greater light penetration for algal growth and lower levels of settled silt. Hence silt-tolerant taxa are likely to have a small competitive advantage on the southern reef.

Teasing out the influence of depth is more complex in this instance since the transects vary so much in profile from steep (PR1, PR2) to almost flat (PR3, PR5) and the change in average transect depth along the reef is in fact very small. In examining the data from the 2016 survey, Sneddon et al. (2017) looked at variability in occurrence with depth and found broad trends only for several of the most dominant taxa. The

most conspicuous of these included the kelp *Ecklonia radiata* and green-lipped mussels. The occurrence of these two species appears mostly related to the inclusion of shallow wave-washed areas within individual transects rather than to physical gradients operating over larger spatial scales.

Topographical effects are also difficult to examine. Like depth, changes in topography (from high to low-relief) do occur along the reef; however, these changes are not dramatic and topography varies from transect to transect.

3.1.5. Differences between surveys

Newly recorded and absent taxa

There were 21 taxa that were newly recorded in the 2019 survey. Of these, 15 were sessile species. Ten of the new taxa achieved a total abundance score of 3 or more (meaning they were recorded across more than two transect segments, occasional in at least one of two segments or common in one segment). These taxa are listed in order of decreasing prevalence in Table 3, together with details of their occurrence.

Table 3. Taxa recorded in 2019 (with an overall abundance score > 2) that were absent from the 2016 survey record.

Description	Scientific name	Score	2019 transects	Incidence
Red-mouthed ascidian	Ascidiacea sp. A	65	PR2,5,6,4,7,8	Common at the 4 southern transects
Encrusting bryozoan		37	PR1,7,8	Locally common
Red encrusting sponge	cf. *Stylopus australis*	11	PR8	
Globose sponge	cf. *Aaptos globosa*	9	PR5,6,4,7	Consistently single isolated individuals
Branching sponge	cf. *Iophon minor*	6	PR8	Rare to common
Red encrusting algae		4	PR2	First 50 m, R - O
Orange honeycomb sponge		4	PR8	Consistently single isolated individuals
Green algae (grass-like)		3	PR2	Two segments, R - O
Orange massive sponge	cf. *Hymeniacidon* sp.	3	PR2,8	Single isolated individuals
Pink sponge conulose,	cf. *Dendrilla rosea*	3	PR2,5,6	Single isolated individuals

The presence of the small red-mouthed solitary ascidian (Ascidiacea sp. A) was discovered only in the review of transect photographs as it is small and easily overlooked by divers despite high local densities in patches. Examination of photographs from 2016 also identified its (previously unrecorded) presence. Due to differences in the photographic record between surveys, it was not possible to assess whether its prevalence had changed.

Like Ascidiacea sp. A, encrusting bryozoans can be easily overlooked, more so in conditions where they may be obscured by settled silt. They are also more difficult to identify from the photographs. It is unlikely that they were not present in 2016 or that they were limited to the three transects they were observed in the current survey (Table 3).

It is likely that the globose sponge (cf. *Aaptos globosa*) was mis-identified in 2016 as the pink golf ball sponge *Tethya bergquistae* which it resembles. A review of the photographs from the earlier survey confirmed that it was present.

While it was recorded in 2016 from a single occurrence at PR6, the small fan bryozoan cf. *Caberea zelandica* was more often identified from the current survey, but mostly from review of the photographs. Review of the 2016 photographs indicated that it was also more widely present in the southern reef transects than was recorded by divers at the time.

Of the sessile biota previously recorded in 2016 but not in the current survey (Table 4), all were limited to only one or two transects and of rare or occasional abundance status. Two (*Ectopleura* sp. and *Coscinasterias muricata*) were recorded from Town Reef in 2019 (Appendix 3). The horse mussel (*Atrina zelandica*) is not a reef species and was recorded in 2016 (as rare to occasional) only from PR5 and PR8 in segments where there was sufficient sand for their establishment.

Table 4. Sessile biota recorded in 2016 that were absent from observations for the current survey.

Common name	Scientific name	2016 transects	Incidence
Solitary hydroid	*Ectopleura* sp.	PR8	Single instance
Encrusting hydroid	cf. Bougainvillidae	PR5, PR6	Occasional to rare
Cup coral (solitary)	*Monomyces rubrum*	PR8	Single instance
Horse mussel	*Atrina zelandica*	PR5, PR8	Occasional to rare
11-armed seastar	*Coscinasterias muricata*	PR3, PR7	Rare

Changes in prevalence

By subtracting the transect scores for individual taxa in the 2016 survey from those of the current survey, an indication could be gained of where general changes may have occurred. For most species, small to moderate negative changes in some transects were balanced by positive changes in others, with no spatial pattern indicated. Taxa that were under-represented in 2016 for methodological reasons have been discussed above (e.g. the fan bryozoan and red-mouthed ascidian). More general and consistent changes occurring for other taxa were mostly small but notable for some transects (Table 5).

Table 5. Taxa for which general changes in prevalence were indicated by the relative abundance record when compared to the results of the 2016 survey.

General decrease in prevalence	
Red algae (*Plocamium cirrhosum*)	small decreases on all but the northern-most two transects
Small blade red foliose algae	decrease on the southern-most three transects
Yellow tubular sponge (*Ciocalypta* sp.)	small decreases on all but the northern-most two transects
Lobed grey sponge (cf. *Thorecta* sp.)	small decrease consistent across southern transects
Orange finger sponge (*Raspalia topsenti*)	notable decreases at PR4, PR8
Branching bryozoan (cf. *Cellaria tenuirostris*)	notable decreases at PR5, PR3, PR7
General increase in prevalence	
Yellow boring sponge (*Cliona* cf. *celata*)	notable increases at PR1, PR3
Orange bryozoan (*Steginoporella* sp.)	general small increase but marked at PR1, PR3

Because of the subjective aspects of the assessment of relative abundance, some of these changes in patterns of occurrence are likely to be at least partly related to human judgement. However, active measures were taken to minimise such bias, including having the same divers compiling the observational record in both surveys and re-familiarising field workers with the 2016 photographic record before the dives.

Fish were generally less prevalent in the current survey, including some species that are reliably ubiquitous, such as spotted wrasse (*Notolabrus celidotus*) and triplefins. Since underwater visibility was not consistently poorer in the current survey, this is not readily explainable. Other species that were notably more common in 2016 included the butterfly perch (*Caesioperca lepidoptera*), red moki (*Cheilodactylus spectabilis*) and blue cod (*Parapercis colias*).

3.2. Town Reef transects

The three Town Reef transects were dived on 26 May 2019. Conditions were calm with little swell. The depth profiles, taken from one of the diver's wrist-mounted computers, are shown in Figure 12. The first transect (TR1) did not descend below water depths of 8 m and was distinctly different from the two subsequent, deeper transects (TR2 and TR3). TR1 featured notably less settled silt and good light penetration to the seabed. In contrast, underwater visibility was limited for TR2 and TR3, but still considered good for this location.

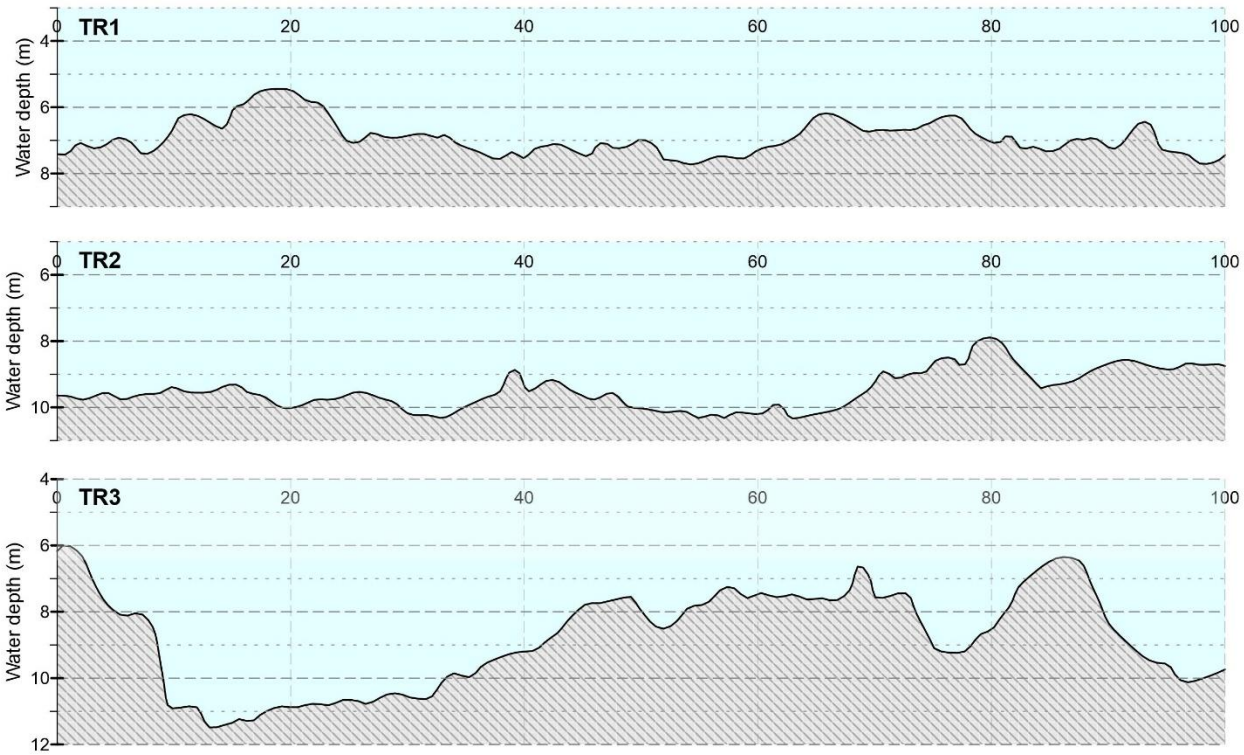

Figure 12. Depth profiles for the three Town Reef transects (unadjusted for tidal variation). The distance-based abscissa is derived from the time-based dive computer profile and assumes that the diver was moving at constant speed throughout the 100 m transect.

3.2.1. Description of habitats and communities

Between 300 and 400 photographs of substrate and biota were taken along each 100-m transect. From the review of these images, along with continuous video coverage and post-dive notes on observations, a descriptive characterisation was compiled for each transect. These are provided in the following sections, together with associated profile figures divided each into four 25-m sections for each transect. The subset of photographs presented (32 per transect) have been chosen from the total image set as being broadly representative of taxa and habitats. Photograph locations along the depth profile have been established from synchronisation of the camera and dive computer time records. The complete inventory of taxa recorded across the three transects is listed in Appendix 3.

Dive transect TR1

Profile: Water depths were consistently less than 8 m.

Conditions: Good visibility during the dive (2–3 m). Good light penetration to the seabed. Some surge was evident in the video but not problematic for divers.

Terrain: Similar terrain occurred throughout the transect. Plentiful rock outcrops, ledges and low overhangs forming recesses against surrounding bedrock and gravel pockets. Some embedded boulder terrain with cobble-strewn sandy clearings amongst kelp / *Ecklonia*.

Coarse sand collected in pockets and niches. Where these pockets were sufficiently protected from water movement, the sediment appeared stable (non-mobile). Where there were more open expanses of gravelly sand between rock outcrops and in low level areas, the sediment appeared mobile. There were occasional small patches of cobble material.

Silt presence: Settled silt was not prominent except where it occurred in deeper recesses and niches protected from water movement.

Macroalgae: Abundant and healthy kelp / *Ecklonia* occurred along the entire transect. Fronds occasionally supported fine white hydroids. While not particularly dense, there was enough *Ecklonia* to hinder diver progress at the seabed and occasionally obscure the view ahead. *Ecklonia* recruits were common, as were low clumps of foliose red algae (*Plocamium* sp.).

Encrusting algae: Pink coralline algae were notably conspicuous on bedrock and boulder high points. Not universal coverage but enough to represent a dominant visual effect. Prevalence of dark-red non-coralline encrusting red algae (cf. *Hildenbrandia*), interspersed with coralline algae, was notable and, in places, gave exposed surfaces a mosaic quality.

Notable encrusting life: Encrusting life was plentiful although there was evidence of scour or smothering around areas of mobile gravel and sand. Colonies of serpulid worms occurred occasionally on vertical rock faces or beneath overhangs.

Dense beds of mature green-lipped mussels were recorded in a shallower bedrock area near the 20-m mark.

Colonial ascidians (*Didemnum,* cf. *Synoicum otagoensis*, *Eudistoma* sp.) were common. The small red-mouthed ascidian (Ascidiacea sp. A) was very plentiful in the patches where it occurred. *Pyura spinosa* were present on exposed surfaces but not particularly abundant.

Sponges: *E. alata* was common. Occasional small patches of yellow and cream *Ciocalypta* sp., as well as both pink and orange *Tethya,* were frequently observed along the transect, as was a bright orange encrusting sponge that formed discontinuous patches (see transect photos, Figure 13, 65-100 m). The yellow boring sponge (*Cliona*) occurred mainly in association with coralline algae.

Mobile invertebrates: Crayfish were frequently seen beneath ledges. An octopus (*Macroctopus maorum*) was photographed, along with biscuit stars (*Pentagonaster pulchellus*), cushion stars (*Patiriella regularis*), and both seven- and eleven armed stars (*A. scabra* and *C. muricata*). Cook's turban shell (*Cookia sulcata*) was observed and aggregations of kina.

Fish life: Triplefins were more prevalent than at the Pania Reef transects. Red moki, scarlet wrasse and banded wrasse were recorded. Fish life in general was more plentiful than had been observed at south Pania Reef, although butterfly perch and sweep were not observed at TR1.

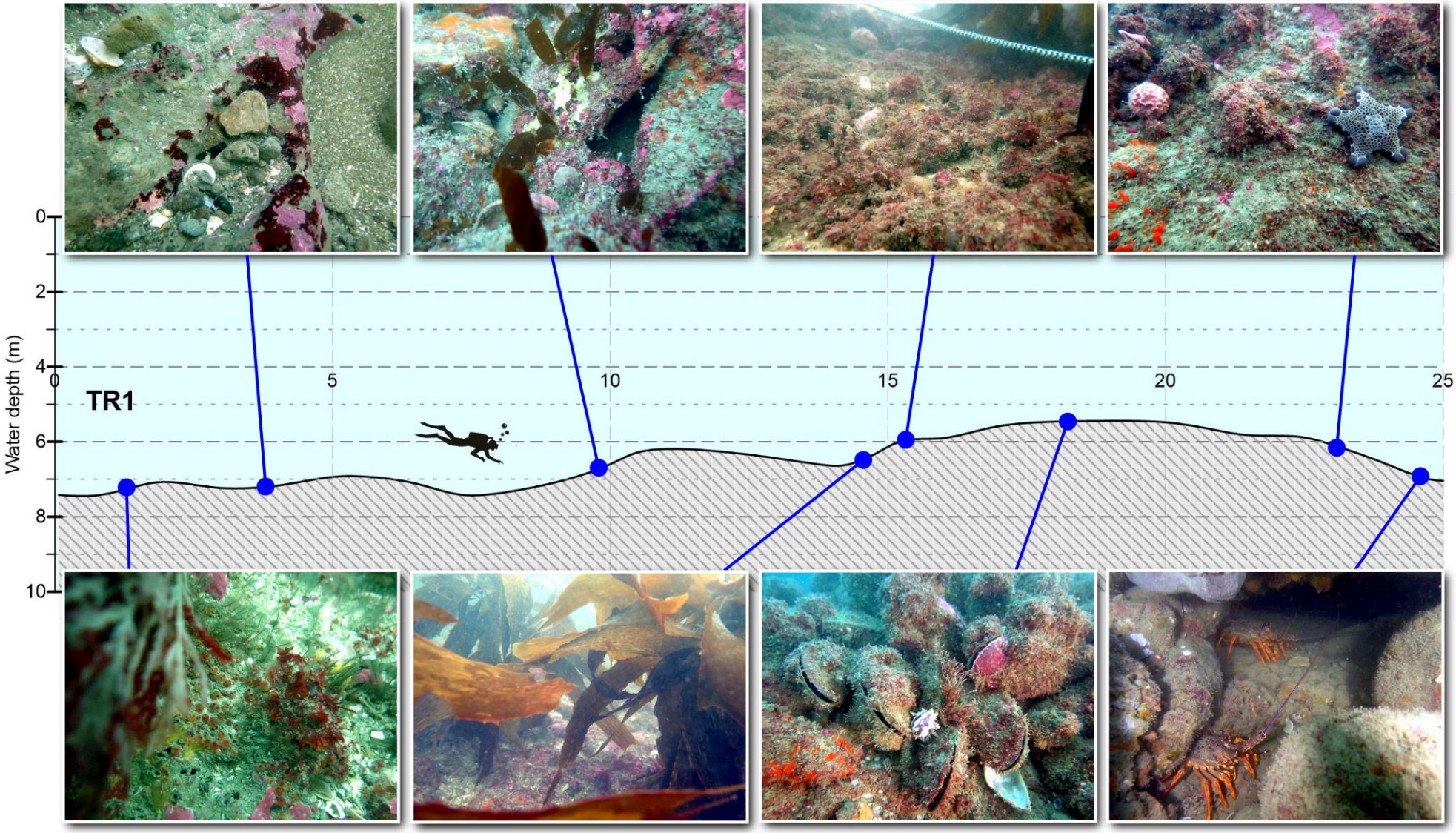

Figure 13. Depth profile with photographs of representative habitat along transect TR1. **A:** First 25 m section (0–25 m). The photographs were chosen to illustrate representative habitat and located (blue pointers) according to the digital image time stamp synchronised to the dive computer record of depth. Grey dashed line and numbers show distance along transect.

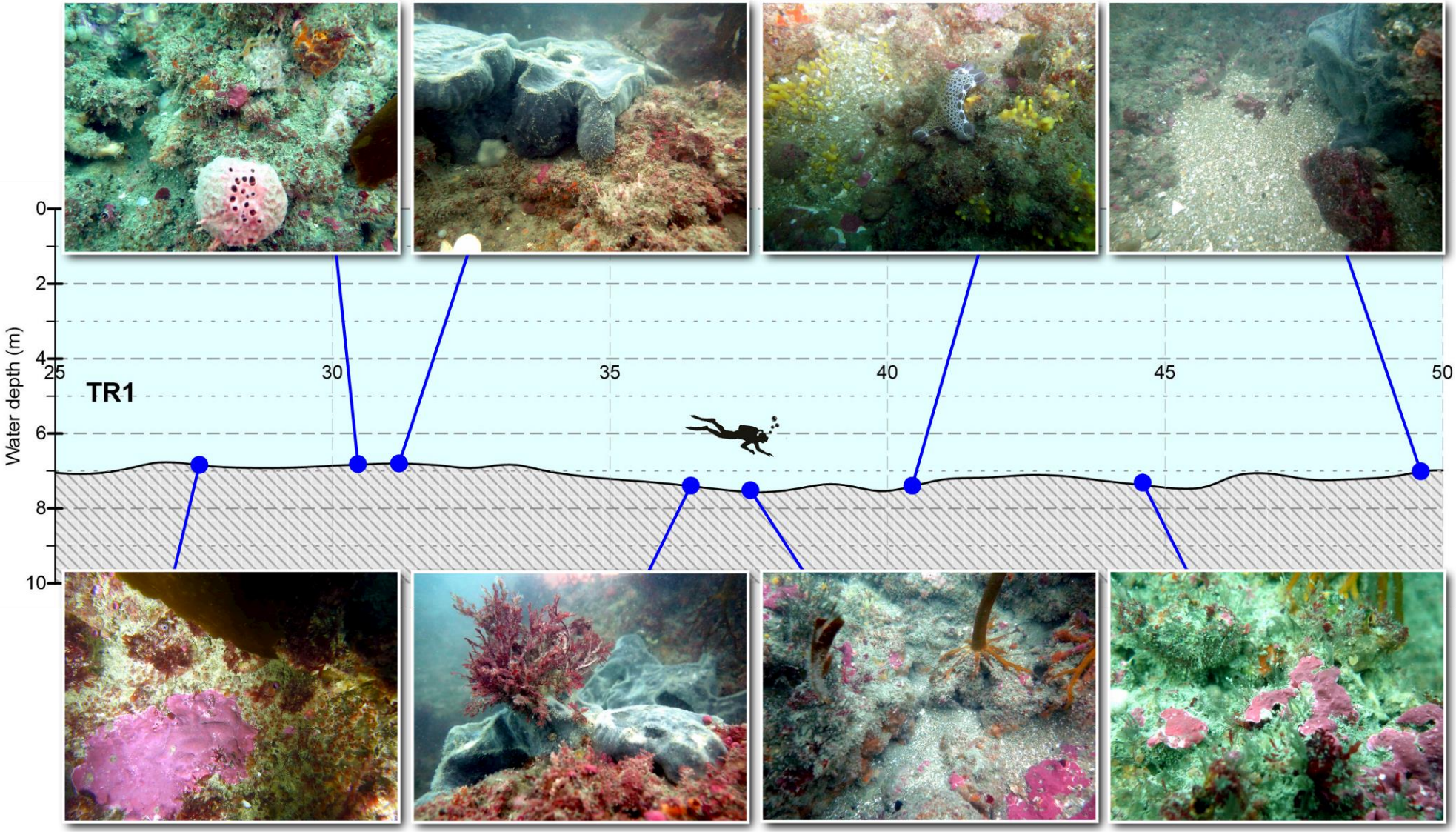

Figure 13 contd. Depth profile with photographs of representative habitat along transect TR1. **B:** Second 25 m section (25–50 m).

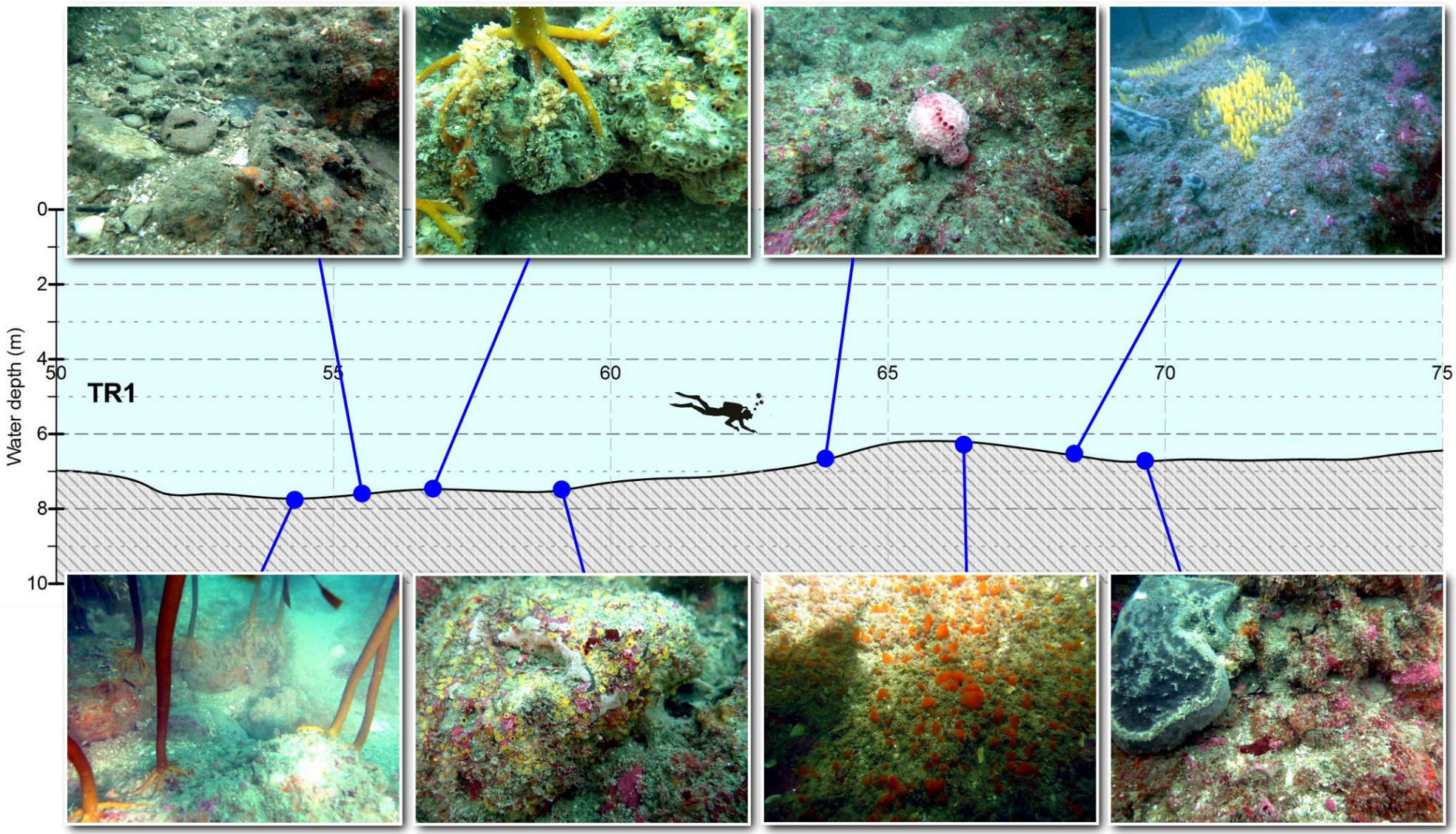

Figure 13 contd. Depth profile with photographs of representative habitat along transect TR1. **C:** Third 25 m section (50–75 m).

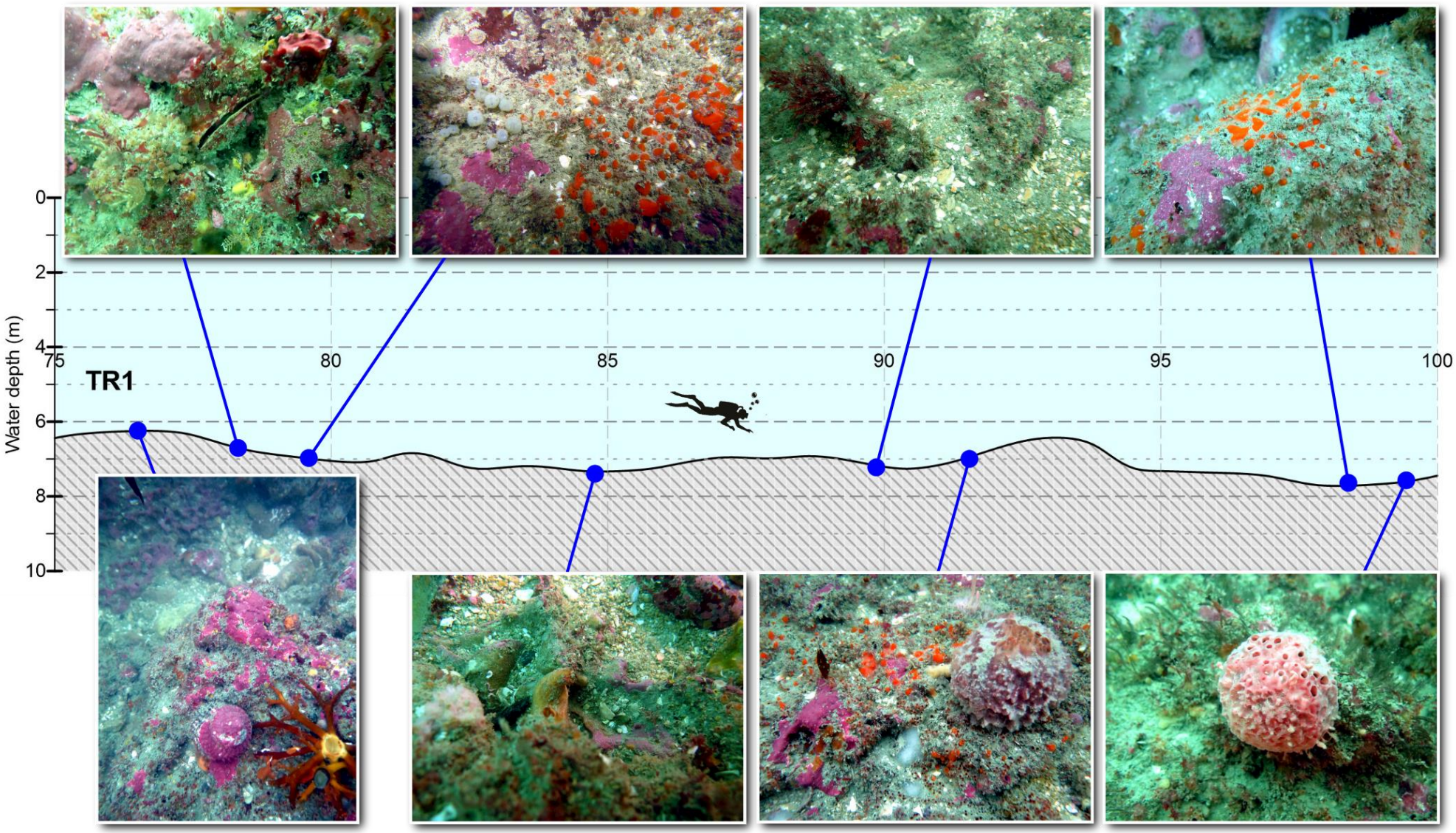

Figure 13 contd. Depth profile with photographs of representative habitat along transect TR1. **D:** Fourth 25 m section (75–100 m).

Dive transect TR2

Profile: Water depth was greater than at TR1, fluctuating around 10 m for the first 70 m of the transect. The seabed rose only briefly to 8 m at the 70-m mark, before descending to 9 m.

Conditions: Underwater visibility of 1.0–1.5 m, significantly poorer than at TR1.

Terrain/substrate: Broadly similar to transect PR8 on south Pania Reef, mostly uneven bedrock with frequent outcrops and ledges. The reef had lower relief and less conspicuous biota between the 20 m and 30 m marks. There were coarse-sand patches and pockets with a shell-hash component (often as a thin layer over bedrock). Ledges and outcrops were more prominent from 45 m. Sand was more prevalent from 70-80 m, with pronounced ripples indicative of wave disturbance. Some cobble/pebble substrate occurred at the 90 m mark.

Silt presence: Notably siltier than transect TR1. Settled silt occurred in hollows and low points. Silt entrapped within encrusting biota gave a monochrome (dun-coloured) effect to low-lying reef substrates, accentuated by poor visibility. Silt could easily be stirred up by hand.

Macroalgae: Kelp / *Ecklonia* was not abundant along the transect. Only eight isolated plants occurred in the first 80 m, then a small stand of approximately 20 plants. All were relatively stunted but mature and healthy in appearance. A patch of single-bladed *Ecklonia* recruits was also observed at the 80 m mark. Frequent small clumps of the red alga *Plocamium* sp. occurred, most prevalent from 40 m to 60 m along the transect.

Encrusting algae: Pink coralline alga was consistently present but sometimes at a low level. Occasionally, it was quite prevalent in small dispersed patches, especially in the 3rd quarter of the transect, where it was interspersed with non-coralline encrusting red (Figure 14C).

Notable encrusting life: Except where surfaces had been kept clear by water movement, encrusting life was conspicuously silt-tolerant (psammophytic[5]). Green-lipped mussels were absent for most of the transect length (possibly due to the depth and absence of high points) although a small cluster were recorded at the 90 m mark. Feather hydroids were commonly seen; these occasionally reached quite high densities in patches. Jewel anemones (*Corynactis australis*) formed occasional small aggregations on outcrop faces. Colonial ascidians (cf. *Synoicum otagoensis*, *Eudistoma* sp.) were also commonly seen. The small red-mouthed ascidian was occasionally abundant in patches. The orange bryozoan (cf. *Steginoporella* sp.) was present, but not as common as had been observed at south Pania Reef.

Sponges: In the absence of large macroalgae, sponges were among the most conspicuous encrusting biota. Notable species included *E. alata, R. topsenti, A.*

[5] Encrusting biota such as some sponges and red filamentous and turfing algae, are not only capable of adjusting to sediment stress, but also modify their habitat by trapping and binding sediment (Airoldi 2003).

globosa and *Tethya bergquistae.* The erect branching sponge (cf. *Iophon minor*) was more prevalent here than on south Pania Reef. The boring sponge (*Cliona* sp.) was associated with coralline algae. Lilac sponge (Demospongiae D) was frequently observed. Emergent *Ciocalypta* sp. occurred from the 20 m mark, usually associated with thin mobile sand layers and entrapped surface silt.

Mobile invertebrates: Crayfish were occasionally seen in recesses under ledges. Seven-armed star (*Astrostole scabra*), biscuit star (*P. pulchellus*), kina, Cook's turban shell (*Cookia sulcata*) and sea cucumbers (*A. mollis*) all featured along the transect.

Fish life: Marblefish and triplefins were recorded but poor visibility limited the extent to which fish could be observed.

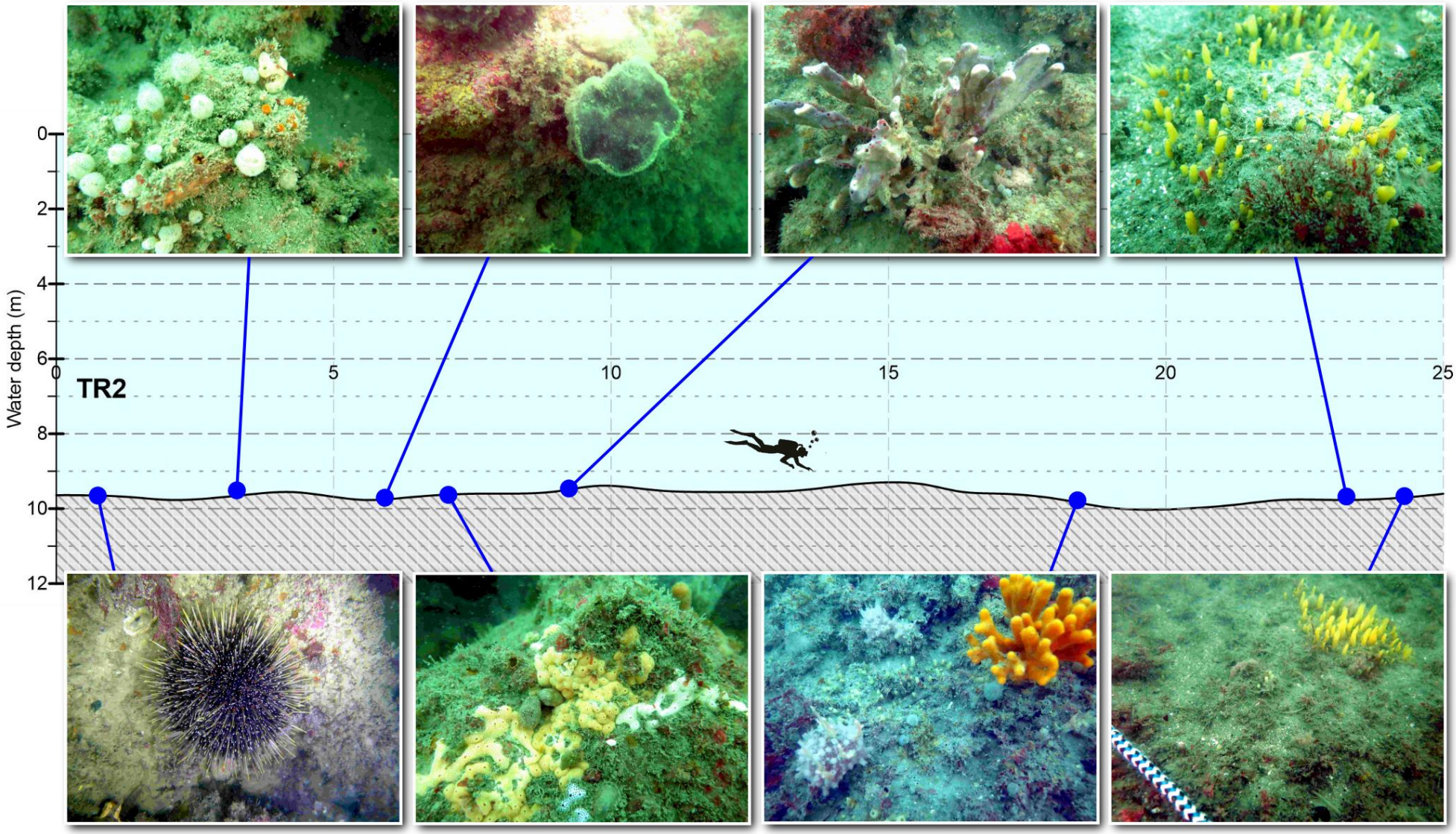

Figure 14. Depth profile with photographs of representative habitat along transect TR2. **A:** First 25 m section (0–25 m). The photographs were chosen to illustrate representative habitat and located (blue pointers) according to the digital image time stamp synchronised to the dive computer record of depth. Grey dashed line and numbers show distance along transect.

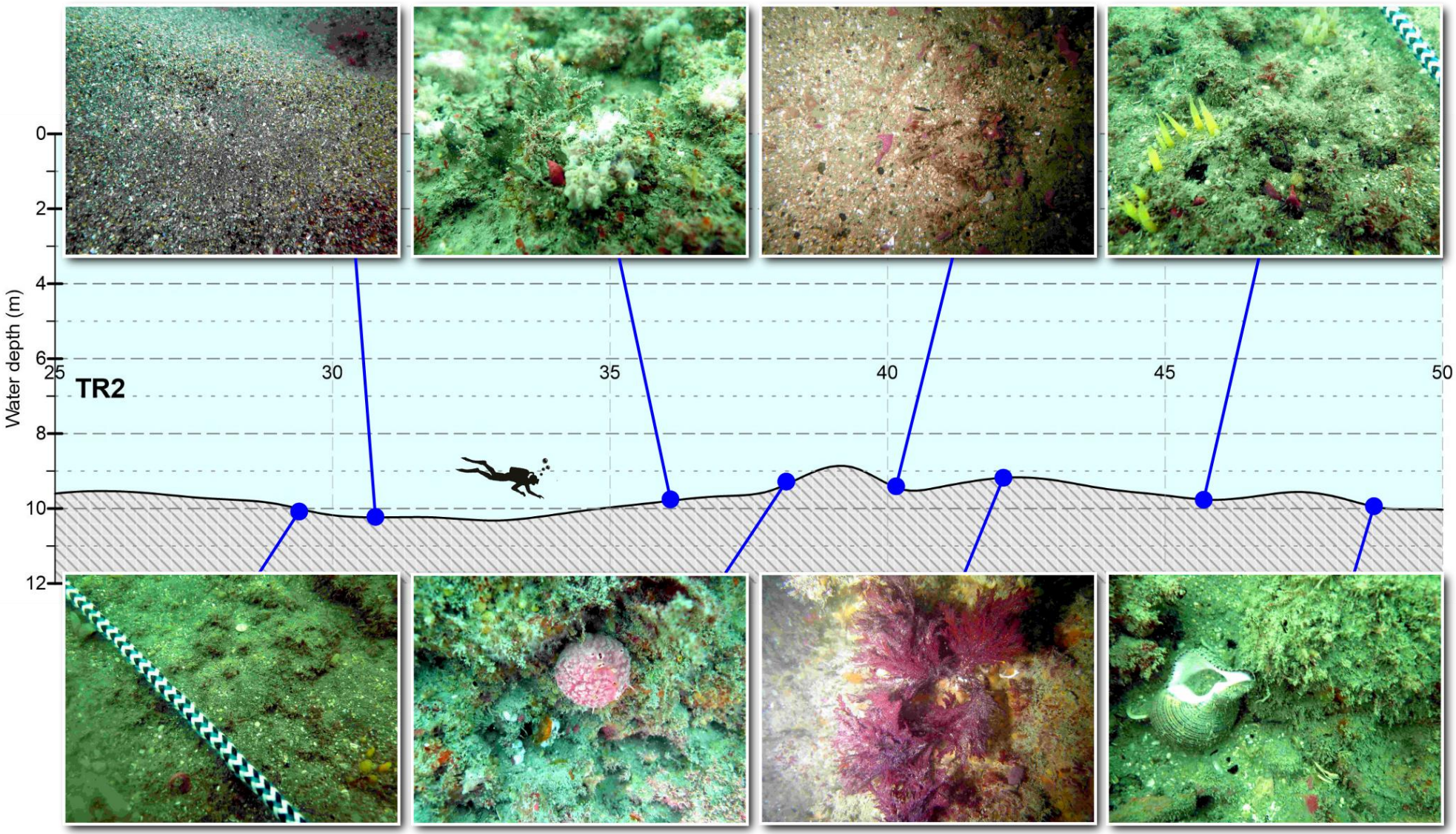

Figure 14 contd. Depth profile with photographs of representative habitat along transect TR2. **B:** Second 25 m section (25–50 m).

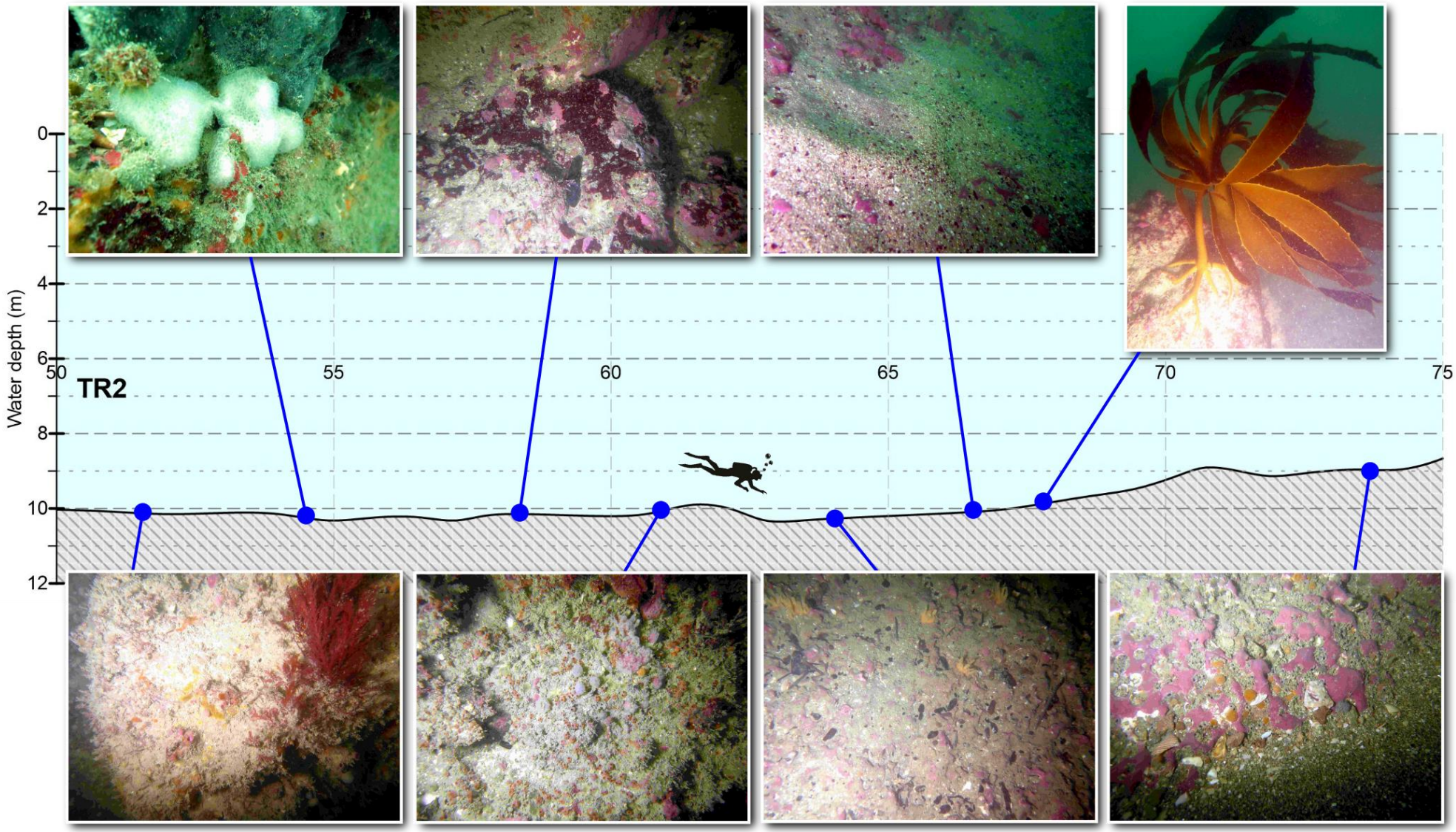

Figure 14 contd. Depth profile with photographs of representative habitat along transect TR2. **C:** Third 25 m section (50–75 m).

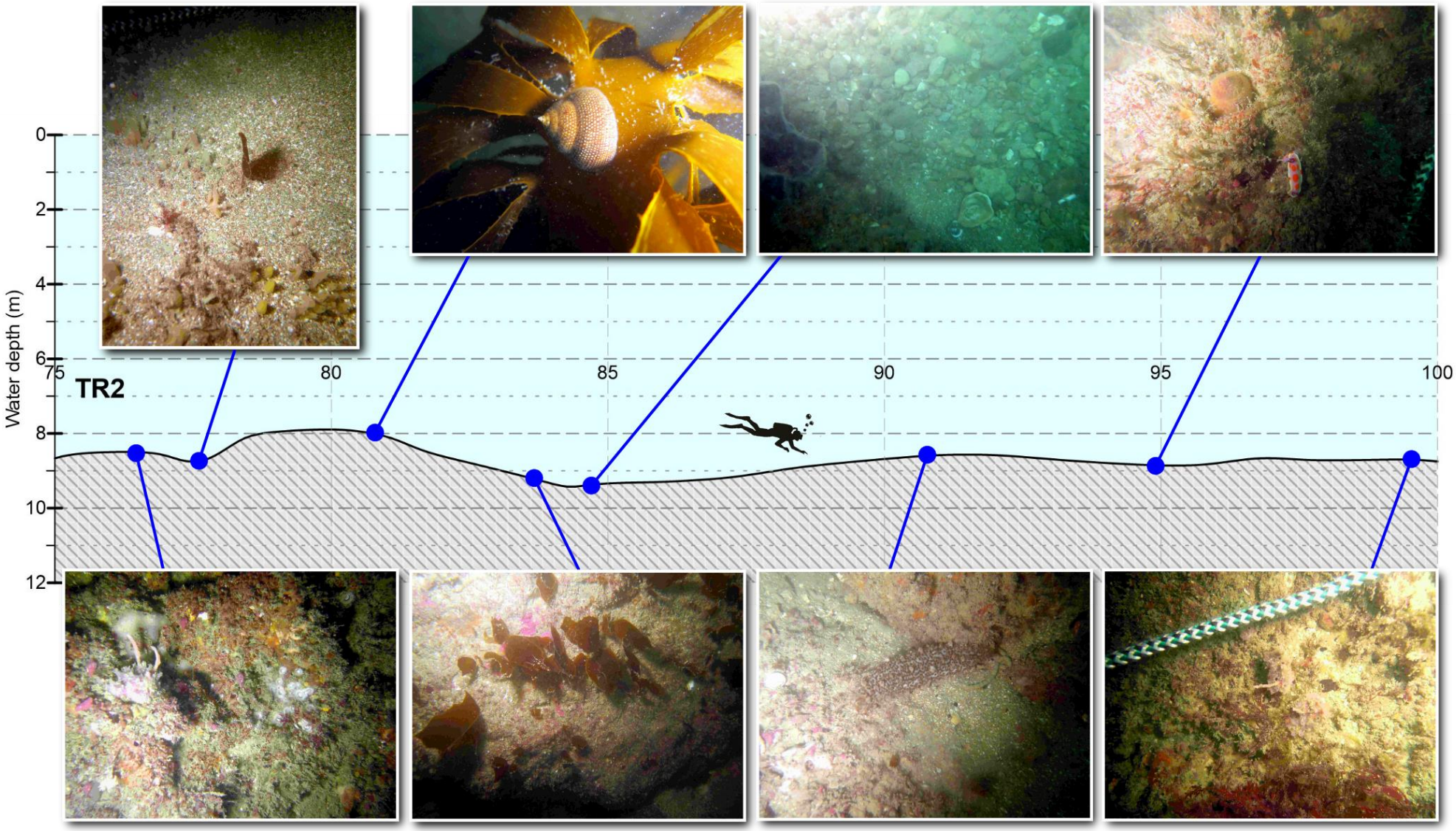

Figure 14 contd. Depth profile with photographs of representative habitat along transect TR2. **D:** Fourth 25 m section (75–100 m).

Dive transect TR3

Profile: Transect TR3 had a strikingly variable depth profile (Figure 15), featuring very uneven terrain, valleys and drop-offs.

The transect started in ~6 m water depth on a large rock outcrop but descended very steeply to 8 m, then 11 m. After the 30 m distance mark, water depths varied 6 m to 10 m for the remainder of the transect.

Conditions: Similar to conditions for transect TR2, divers had poor visibility (1-1.5 m). Suspended particulate matter was notable from review of the video recordings.

Terrain/substrate: At depths below 8 m, benthic conditions were similar to TR2. There were patches and more open stretches of coarse mobile sand, as well as patches of silty sand in niches more sheltered from water movement. Pockets of mobile sand occurred among bedrock ledges. Some small-boulder substrate was observed confined between ledges after the 70 m mark. At the 100 m mark, wave-rippled sand indicated the effects of swell at ~10 m water depth.

Silt presence: Similar to transect TR2, TR3 was noticeably siltier than TR1. In places, entrapped silt was prominent within encrusting biota, leading to a superficially barren appearance until closer inspection of rock surfaces.

Macroalgae: Very little kelp / *Ecklonia* was observed, mostly single isolated plants that were relatively stunted but healthy in appearance. Clumps of *Plocamium* occurred at similar frequency to TR2.

Encrusting algae: Coralline algae occurred in sporadic patches but was not generally prevalent along the transect.

Notable encrusting life: The shallow (6 m) outcrop at the start of the transect was covered in a dense bed of mature green-lipped mussels. This extended to a deeper adjacent ledge where mussel beard hydroid (*Amphisbetia*) was prominent. A further dense mussel bed was observed at a raised point between the 80 m and 90 m distance marks. Otherwise, communities were similar to those of TR2. Jewel anemones (*Corynactis australis*) were present in patches. A small patch of the solitary hydroid *Ectopleura* sp. was observed just before the 30 m mark. The saddle squirt *Cnemidocarpa* sp. was common along the transect, as were feather hydroids and the small red-mouthed ascidian (Ascidiacea sp. A). Orange bryozoans (*Steginoporella* sp.) and the stalked ascidian (*P. spinosa*) were occasional and the clown's hair bryozoan (Catenicellidae) was also observed.

Sponges: Commonly occurring sponges included *E. alata*, *Tethya burtoni, Tethya bergquistae, Raspalia, Aaptos globosa* and lilac Demospongiae D. The branching sponge (cf. *Iophon minor*) was more frequent than had been observed at TR2 but would still be categorised as only occasional. Emergent *Ciocalypta* sp. was associated with embedded silt and shallow sand layers. The yellow boring sponge (*Cliona*) was also present.

Mobile invertebrates: The seven-armed star (*A. scabra*) was observed associated with mussel beds. *P. pulchellus, P. regularis* and sea cucumber (*A. mollis*) were also recorded. Crayfish occurred in recesses beneath ledges.

Fish life: Not many fish were recorded (dwarf scorpionfish, spotted wrasse, triplefins). Like transect TR2, underwater visibility limited the extent to which fish could be observed.

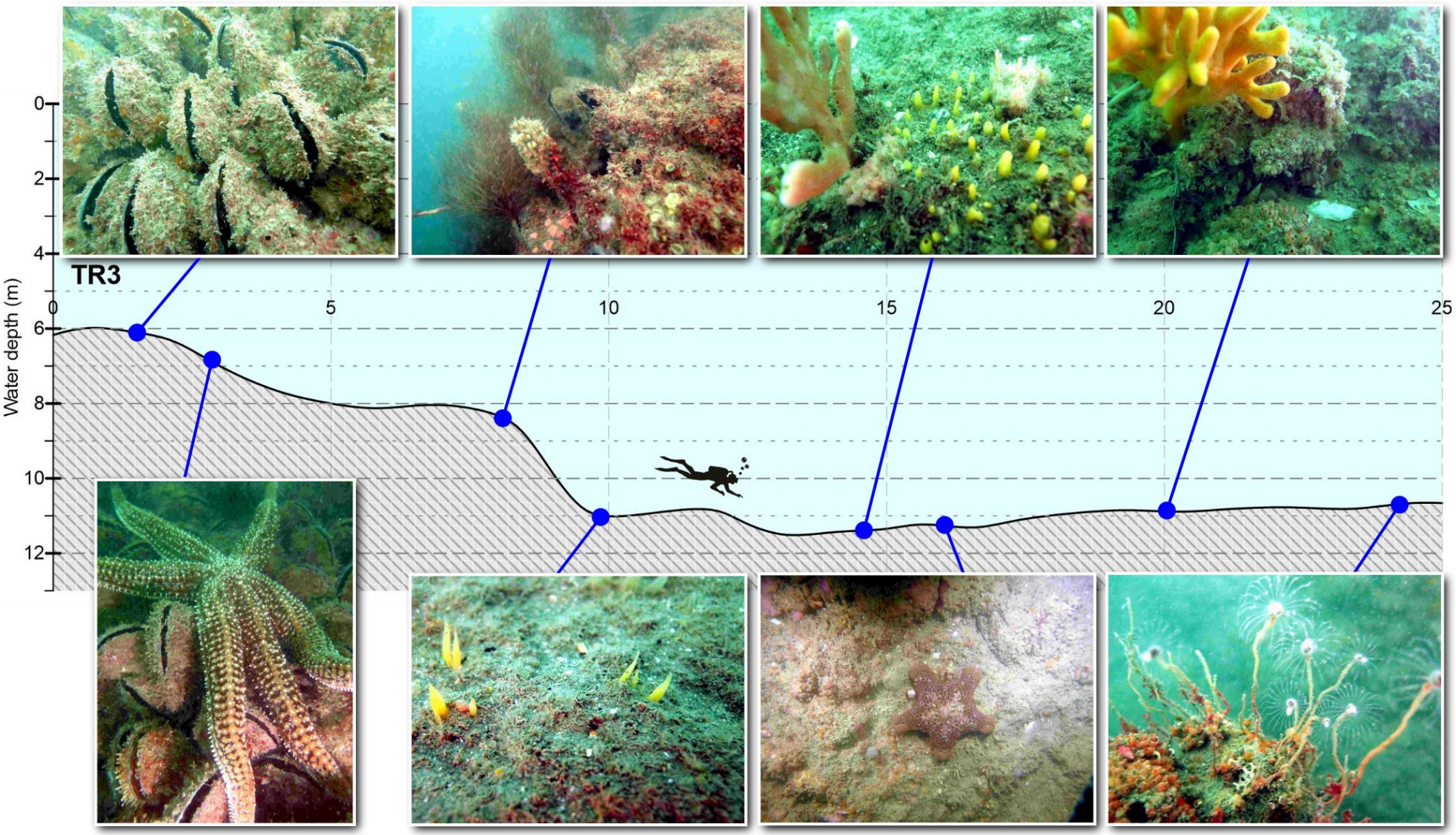

Figure 15. Depth profile with photographs of representative habitat along transect TR3. **A:** First 25 m section (0–25 m). The photographs were chosen to illustrate representative habitat and located (blue pointers) according to the digital image time stamp synchronised to the dive computer record of depth. Grey dashed line and numbers show distance along transect.

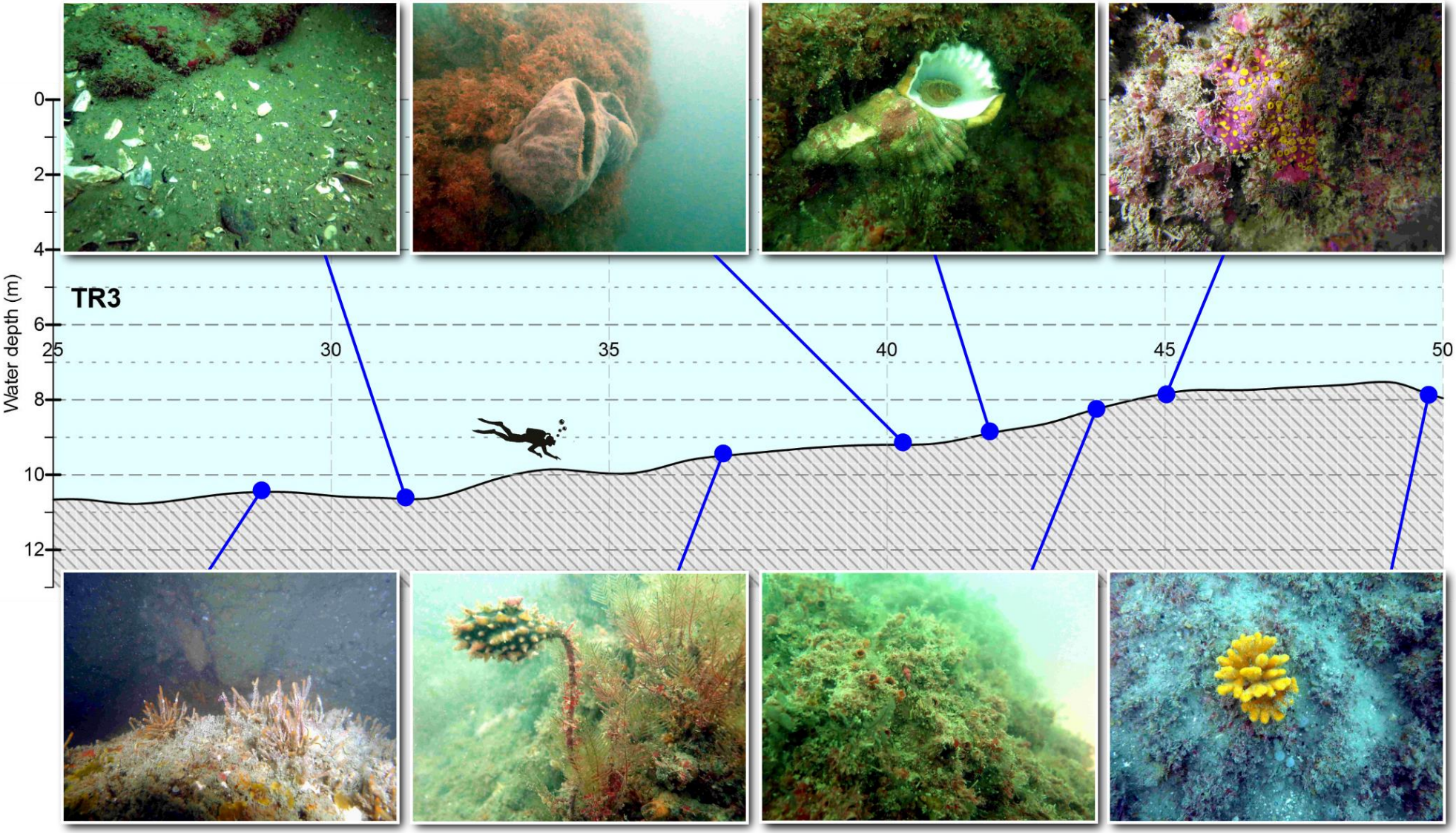

Figure 15 contd. Depth profile with photographs of representative habitat along transect TR3. **B:** Second 25 m section (25–50 m).

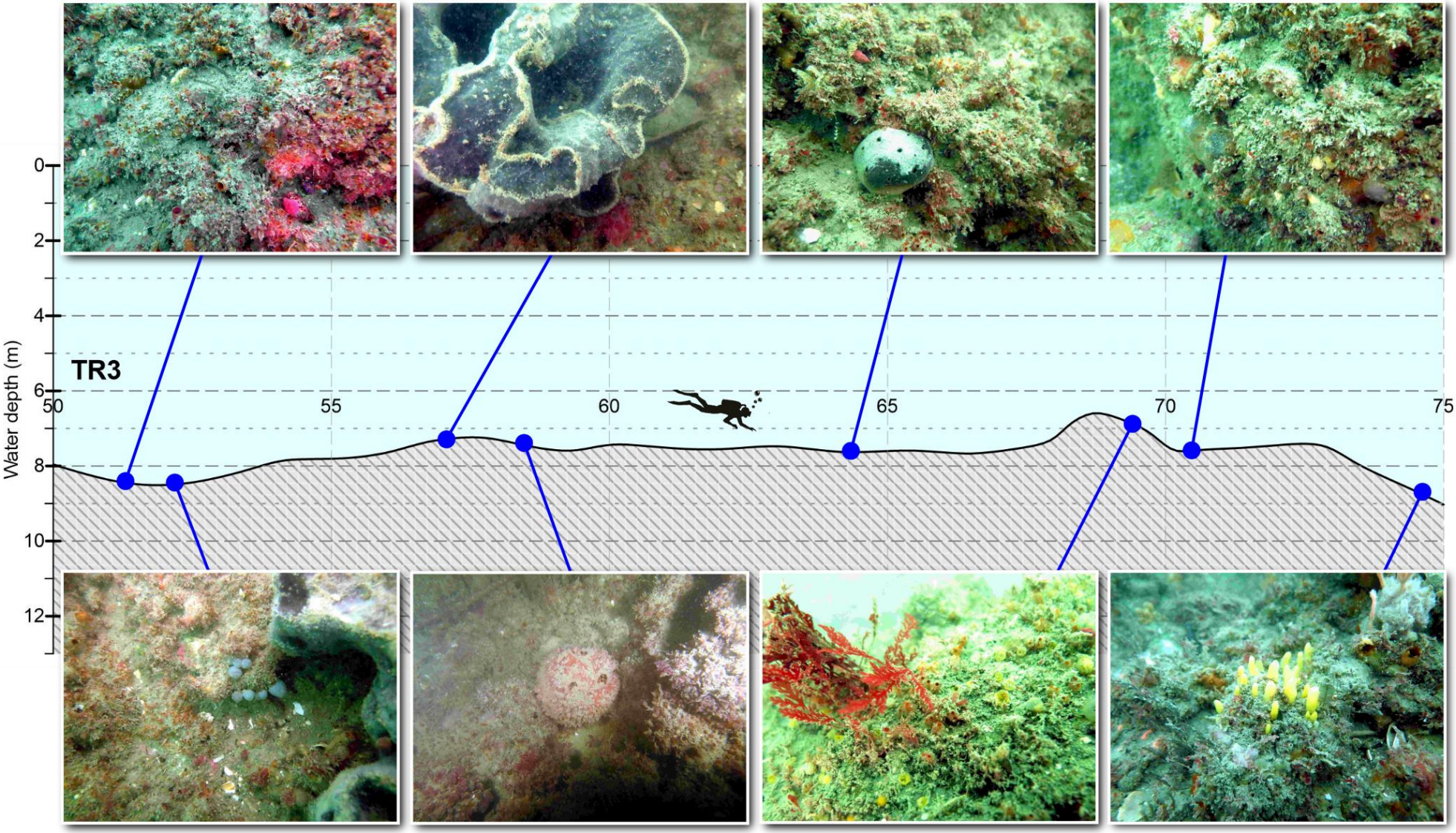

Figure 15 contd. Depth profile with photographs of representative habitat along transect TR3. **C:** Third 25 m section (50 –75 m).

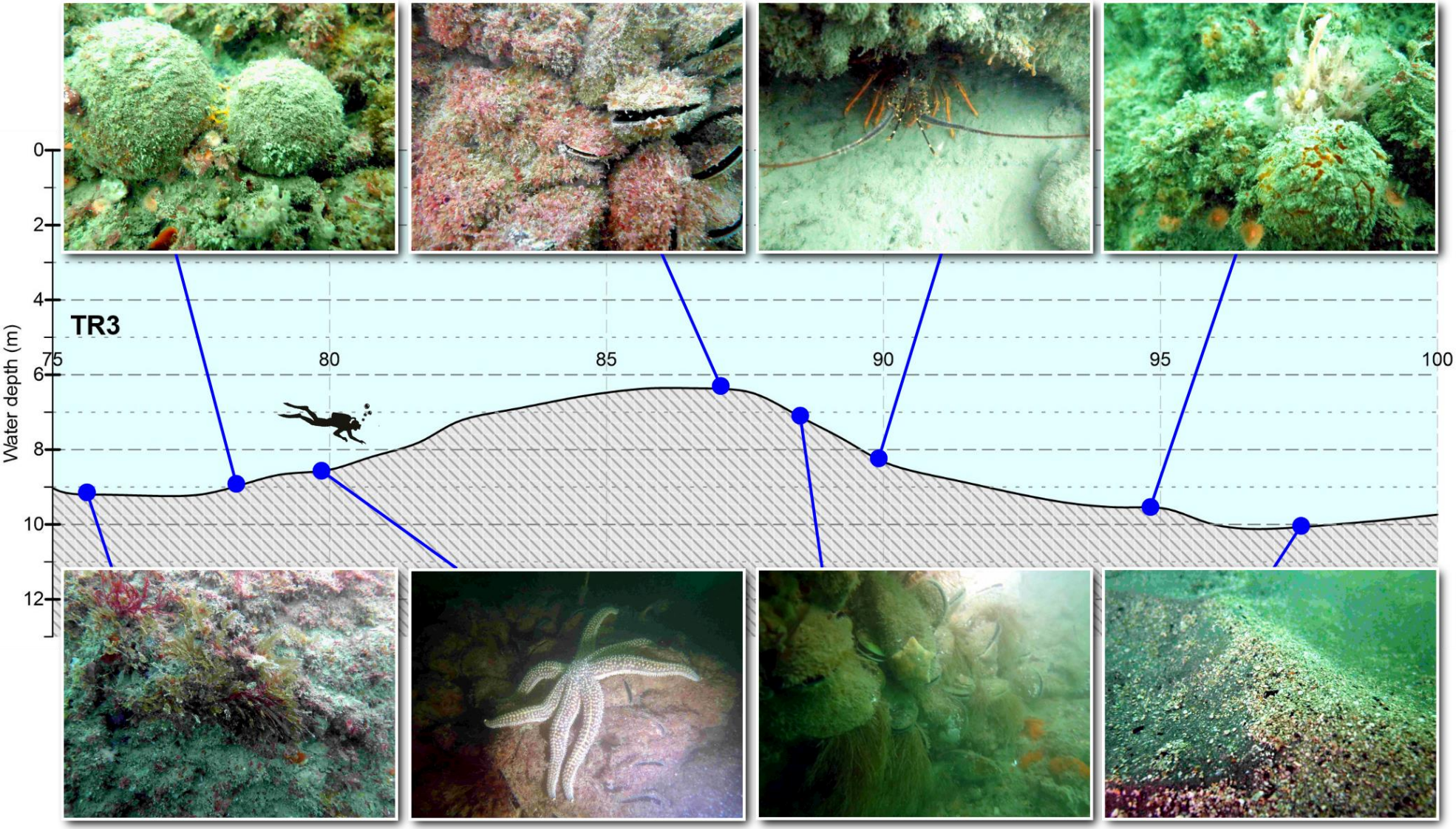

Figure 15 contd. Depth profile with photographs of representative habitat along transect TR3. **D:** Fourth 25 m section (75–100 m).

3.2.2. Comparison to Pania Reef transect communities

Since Town Reef effectively represents the inshore section of the Pania/Town reef system, it is useful to consider the similarities and differences observed between the two sets of transects. Overall, the assumption that Town Reef should represent a continuation of gradients observed along Pania Reef was supported by the data.

Few taxa that could be considered characteristic of the Town Reef transects were not also recorded from Pania Reef. Mostly, newly recorded taxa were present as a few individuals at most.

- Small colonies of calcareous tube worms (Serpulidae) were observed at two points along TR1 but it is considered likely that the significantly shallower water depth (and hence greater exposure to water movement) of this transect may be the primary condition supporting their establishment.
- During review of the transect photographs, a small green cnidarian was noted from several images along all three transects. These were not plentiful but had not featured in the Pania Reef record.
- The biscuit or firebrick seastar (*Pentagonaster pulchellus*) was seen on all 3 transects.
- The eleven-armed seastar (*Coscinasterias muricata*) was recorded from TR1.
- An octopus (*Macroctopus maorum*) was recorded from TR1.
- A white nudibranch (unidentified) was recorded (in a single occurrence) from TR2.
- The tower shell (*Maoricolpus roseus*) occurred occasionally along TR2 and TR3.

Taxa that were more abundant at the Town Reef transects included:

- Kina (*Evechinus chloroticus*), especially on TR1.
- Cushion stars (*Patiriella regularis*) – occasional on TR1 and TR2 but recorded from just one individual on transect PR7.
- The red alga *Plocamium* sp. (all three transects).

Several taxa that were present in the southern transects of Pania Reef were notable by their absence from the Town Reef transects. These included:

- A distinctive yellow massive sponge (Demospongiae E) that was a species characteristic of PR7 and PR8.
- A branching erect bryozoan (cf. *Cellaria tenuirostris*) that occurred in several Pania Reef transects, including PR7 and PR8.
- The fan bryozoan (cf. *Caberea zelandica*)

Other sessile organisms that were less frequently observed at Town Reef were:

- Clowns hair or moss bryozoan (Catenicellidae)
- The orange erect bryozoan (cf. *Steginoporella* sp.).

4. SUMMARY OF MAIN FINDINGS

4.1. Pania Reef

There was no evidence of any general increase in accumulated sediments on Pania Reef since the previous baseline survey in 2016 and the prevalence of settled silt was similar. Only two transects showed an increase in sand substrate, both instances being attributed to either the temporary migration of mobile sands into low-lying reef areas or small changes in transect placement.

In most cases, more taxa were recorded per transect in the current survey of Pania Reef than in the 2016 survey. This can partly be attributed to familiarisation with the habitats, biota and methodology by the divers involved (better detection and an increase in taxonomic resolution). However, the non-quadrat photographic record was more comprehensive for the current survey and the practice of augmenting the taxa abundance data from a careful review of these images led to several more taxa being identified than were recorded by the divers.

The differences between the results of the two surveys of Pania Reef were minor overall. The few species that were observed in only one survey generally had low occurrence rates where they were recorded.

A spatial gradient in encrusting reef communities was observed along the reef axis. This included greater incidence of a range of sponges, ascidians and several cnidarians towards the southern (inshore) section of the reef and a lower incidence of two of the more generally abundant bryozoans. The data indicated that this broad spatial gradient extended also to Town Reef.

4.2. Town Reef

Town Reef supported communities very similar to those occurring on the southern part of Pania Reef. Transect TR1 was set apart, however, by its generally shallower water depths (less than 8 m). This factor, and the concomitant greater exposure to wave energy, is considered to be the main driver behind the differences observed.

The two deeper transects at Town Reef (TR2 and TR3) were very similar to PR7 and PR8 on southern Pania Reef. The few taxa that differentiated these areas were minor and generally were observed at only low frequency.

Between TR1 and the two deeper transects, there was a marked difference in underwater visibility, the prevalence of settled silt and light penetration to the seabed. This was again attributed to greater water movement at TR1 that prevented fine sediments from accumulating on reef surfaces. Even at TR2 and TR3, water

movement appeared to prevent the accumulation of free settled silt. Benthic silt tended to be trapped by encrusting biota or in deeper fissures and hollows.

Turbidity and depositional conditions for the current survey represent a snapshot in time, so caution must be exercised in any assessment as to how they might vary. However, the taxa inventory and photographic record compiled for Town Reef represent a sound basis from which to assess change in reef communities over time.

5. ACKNOWLEDGEMENTS

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7. APPENDICES

Appendix 1 Notes on the generation and interpretation of representative photographs of substrate and taxa from ecological survey dives.

Limited underwater visibility meant that the Pania Reef photoquadrat record was of limited use in identifying all but the larger encrusting biota. In order to provide some of the detail required at a finer scale for post-dive review purposes, an effort was made to compile a photographic record of taxa and substrate using Canon G16 PowerShot compact digital cameras carried by divers. Wide angle digital photography can compensate somewhat for turbid conditions by enabling subject-object distances to be minimised. However, the amount of suspended material in the water means that flash lighting cannot be used with a small compact camera due to reflection from water column particulates. This in turn makes colour (and detail) of the resulting images very subdued. By using image manipulation software (Corel™ PhotoPaint), the approximate colour balance can be restored and some of the detail brought out of the image. Examples are shown below (Figure A1) of images before and after such post-processing.

It is important to note that the colour-adjusted images in this report are not what the diver sees; they overstate the degree of visual resolution possible with the human eye. The enhanced colours are also oversaturated in order to bring out maximum detail. Many of the photographs are shot in extreme close-up and a scale context may be absent. Most take in less than 0.25 m^2 of the substrate.

It is further important to note that there were unavoidably subjective aspects to the process by which the photographs were taken, especially on Pania Reef. Subjects were photographed because they were points of interest to the diver (representative or otherwise noteworthy taxa and substrates). There is also a possible bias towards composition (i.e. relatively featureless substrates are more likely to have been passed over). These biases can combine to give an impression of potentially higher ecological diversity than the reality. The quadrat photographs were far less likely to incorporate bias as they were constrained to a strict spatial framework that disregarded the nature of the subject being photographed.

Because there was no photoquadrat record generated for Town Reef, a greater focus was placed on photos taken by compact camera and correspondingly more control of the photographic record was taken. Divers were instructed to take photographs at a constant rate, regardless of subject, and move along the transect at as near as possible to a constant speed. This, and the recording of accompanying near-continuous video throughout the dive, is likely to have limited the amount of subject bias in the record.

Finally, the larger macroalga kelp (*Ecklonia*) found in many of the transects is likely to be under-represented in both photoquadrats and compact camera photographs. This is related to scale. The turbid conditions meant that it was often not possible to take photographs which could show *Ecklonia* forest habitat at a large enough scale to represent its extent and density.

Figure A1. Example photographs from Town Reef before (left) and after (right) post-processing with a colour-balancing script to enhance detail.

Appendix 2. Transect abundance scores for individual taxa generated according to categorisations in Table 1. Values represent summations of all abundance codes recorded along each transect for the two surveys (2016 and current), Shading intensity relates to the magnitude of the cell value. At right are the differences between corresponding cell values for the two surveys, shading varying continuously from red (for a substantial decrease in abundance score) through white (no change) to blue (for a substantial increase). Taxa in yellow cells were those newly identified in the current (2019) survey. Transects in north to south order.

	2019 survey transects								2016 survey transects								Difference							
Taxa	**1**	**2**	**5**	**3**	**6**	**4**	**7**	**8**	**1**	**2**	**5**	**3**	**6**	**4**	**7**	**8**	**1**	**2**	**5**	**3**	**6**	**4**	**7**	**8**
ALGAE																								
Ecklonia radiata	17	33	1	30	13	27	8		15	40	2	38	15	24	19		2	-7	-1	-8	-2	3	-11	
Carpophyllum maschalocarpum		20								16								4						
Halopteris sp.	1	10							1	14								-4						
Zonaria sp.		4								8								-4						
Carpomitra costata	1	11								8							1	3						
Coralline paint	13	34		29	8	3	2		11	34		30	16	14		1	2			-1	-8	-11	2	-1
Plocamium cirrhosum	9	13		19	9	18	14	9	7	9	5	22	16	30	19	16	2	4	-5	-3	-7	-12	-5	-7
Pterocladia capillacea		2								3								-1						
Rhodophyta sp. (small-blade red)		1		1	11	4	2	4			1	5		30	11	15		1	-1	-4	11	-26	-9	-11
Red encrusting algae		4																4						
Chlorophyta (grass-like)		3																3						
PORIFERA																								
Ecionemia alata	14	19	14	24	19	25	15	23	12	21	21	21	15	30	18	22	2	-2	-7	3	4	-5	-3	1
Cliona cf. *celata*	12	18		17	7	7		6		11	2			6			12	7	-2	17	7	1		6
Red encrusting cf. Stylopus australis								11					1								-1			11
Orange encrusting cf. *Tedania* sp.	3	5	14	1	2	2	4	10		1			18			8	3	4	14	1	-16	2	4	2
Orange massive cf. *Hymeniacidon* sp.		2						1										2						1
Tethya bergquistae	1		1	1	6	1	7		1	1			5	3	7	4		-1	1	1	1	-2		-4
Tethya burtoni	2	3	3	2	2	5	6	16	3		3	11		16		7	-1	3		-9	2	-11	6	9
Ciocalypta sp.	18	9	6	10	11	10	19	18	11	6	21	16	14	16	21	27	7	3	-15	-6	-3	-6	-2	-9
Lobed grey cf. *Thorecta* sp.	1						2	4					11	1	10	11	1				-11	-1	-8	-7
Raspalia topsenti	11	2	9	8	16	7	15	9	14	2	8	14	15	19	12	22	-3		1	-6	1	-12	3	-13
White/green Demospongiae A			1		1			1		1	1		1					-1						1

	2019 survey transects								2016 survey transects								Difference							
Taxa	**1**	**2**	**5**	**3**	**6**	**4**	**7**	**8**	**1**	**2**	**5**	**3**	**6**	**4**	**7**	**8**	**1**	**2**	**5**	**3**	**6**	**4**	**7**	**8**
Grey Demospongiae B		2		2			1			2	2					1			-2	2			1	-1
Pink Demospongiae C		1		3			1					10						1		-7			1	
Lilac Demospongiae D	2		6	10	11	9	11	21				2	14	13	21	14	2		6	8	-3	-4	-10	7
Yellow Demospongiae E			1	1	3		13	8			9		18	3	18	8			-8	1	-15	-3	-5	
Maroon Demospongiae F	1		1		1								1				1		1					
Latrunculia cf. *procumbens*		4			2	1	2			1				1				3			2		2	
Grey encr. cf. *Ircinia novaezealandiae*		1																1						
Brown massive cf. *Polymastia massalis*							1	1															1	1
Globose sponge cf. *Aaptos globosa*			1		4	1	3												1		4	1	3	
Branching sponge cf. *Iophon minor*								6																6
Orange honeycomb sponge								4																4
cf. *Dendrilla rosea*		1	1		1													1	1		1			
BRYOZOA																								
Bryozoan Catenicellidae	18	12	8	21	12	6	4	3	20	11	2	16	8	3	2	1	-2	1	6	5	4	3	2	2
Bryozoan branching cf. *Cellaria tenuirostris*	8		1	2	4		3	2	6	3	17	24	11	4	16		2	-3	-16	-22	-7	-4	-13	2
Bryozoan fan cf. *Caberea zelandica*			1		5	3	3	1					1						1		4	3	3	1
Orange bryozoan cf. *Steginoporella* sp.	21		11	19	13	7	10	9	1		7		12	2	3	5	20		4	19	1	5	7	4
Encrusting bryozoan	20						15	2									20						15	2
Erect bryozoan cf. *Margaretta barbata*		1						1										1						1
CNIDARIA																								
Feather hydroid cf. *Aglaophenia* sp.	1	1		2	2	3	4	15	1	9	2	15		2	14	9		-8	-2	-13	2	1	-10	6
Solanderia ericopsis			2		1	2										1			2		1	2		-1
Amphisbetia bispinosa	2		4	5	4	3				4		10	6				2	-4	4	-5	-2	3		
Branching / bushy hydroid			3		4	4	11	6	11		3		18	1	2		-11				-14	3	9	6
Ectopleura sp.																1								-1
Hydroid cf. Bougainvillidae											2		1						-2		-1			
Anthothoe albocincta	1	7				1	9	16	2	3					17	16	-1	4				1	-8	
Solitary anemone Undescr.	2						2							1	1		2					-1	1	
Alcyonium cf. *aurantiacum*			1		6		3	7							4	4			1		6		-1	3
Culicia rubeola	4	3	1	3	6	2	1	1	1		1	4					3	3		-1	6	2	1	1

Taxa	2019 survey transects								2016 survey transects								Difference							
	1	2	5	3	6	4	7	8	1	2	5	3	6	4	7	8	1	2	5	3	6	4	7	8
Monomyces rubrum																1								-1
Corynactis australis		1			1													1			1			
Zoanthids			1		1														1		1			
Fine hydroid					1																1			
ASCIDIACEA																								
Pyura spinosissima	1					1	4	1	1	2				1		7		-2					4	-6
Cnemidocarpa sp.	3	6	7	11	3		3	13	6	5	3	16	14	20	11	14	-3	1	4	-5	-11	-20	-8	-1
Ascidiacea sp. A		4	2		17	3	18	21		1								3	2		17	3	18	21
cf. *Synoicum otagoensis*	1		4		1	1	13	13			7		14	2	21	14	1		-3		-13	-1	-8	-1
Eudistoma sp.	1		1		2	1	15	11		5	2		11	5	16	15	1	-5	-1		-9	-4	-1	-4
Cream colonial ascidian cf. *Didemnum*						1	5	1		1				2		3		-1				-1	5	-2
Didemnum (white)				4	7	6	1	9						9		4				4	7	-3	1	5
MOLLUSCA																								
Perna canaliculus	7	16	6	7	17	8	1		4	20	1	12	15	2	13	1	3	-4	5	-5	2	6	-12	-1
Atrina zelandica											3					2			-3					-2
Ostreidae sp.	1		4	1		1	2	1							3	3	1		4	1		1	-1	-2
Bivalve (embedded unid)	1	1	1				1		6								-5	1	1				1	
Cryptoconchus porosus				2		1							1							2	-1	1		
Trochus viridis	2	7		2	2	1		1	1	5				1			1	2		2	2			1
Calliostoma tigris				2	3				1			2			3		-1				3		-3	
Calliostoma pellucida forsteriana			1									1		1		1			1	-1		-1		-1
Calliostoma punctulatum				1	1			2								1				1	1			1
Cookia sulcata	2	4		1					2									4		1				
Astraea heliotropium				1						2		1						-2						
Argobuccinum pustulosum					1	2						1								-1	1	2		
Dicathais orbita	2	2		1						9							2	-7		1				
Buccinulum linea								2		4	1		2		1			-4	-1		-2		-1	2
Penion sulcatus	4	1		6	4	1	2	2	3	1	1	4	4	3	5	3	1		-1	2		-2	-3	-1
Cominella adspersa	1																1							
Whelk (*Muricidea* unid)	1																1							

Taxa	2019 survey transects								2016 survey transects								Difference							
	1	2	5	3	6	4	7	8	1	2	5	3	6	4	7	8	1	2	5	3	6	4	7	8
Cabestana spengleri		1																1						
Ceratosoma amoenum	5	1	1	2	4	4	2	4	1			1				2	4	1	1	1	4	4	2	2
CRUSTACEA																								
Jasus edwardsii		2					2	3								2		2					2	1
Paguridae		1	1	4	2		1	3	3		5	1	3	2	1	6	-3	1	-4	3	-1	-2		-3
Guinusia chabrus								2																2
Barnacle unid.				1			1			2								-2		1			1	
ECHINODERMATA																								
Australostichopus mollis	2	1		1	4		5	1	2	3		2	1	1	7	4		-2		-1	3	-1	-2	-3
Patiriella regularis							1																1	
Pentagonaster pulchellus																								
Astrostole scabra		1		1			1	1										1		1			1	1
Coscinasterias muricata												1			2					-1			-2	
Ophiopsammus sp.			1																1					
Evechinus chloroticus					3					6								-6			3			
OSTEICHTHYES																								
Parika scaber	6	2		1			1		3	3	1	2	1	1			3	-1	-1	-1	-1	-1	1	
Caesioperca lepidoptera	4	6	1	21	11	1	1	6	9	5	9	30	20	4	9	10	-5	1	-8	-9	-9	-3	-8	-4
Cheilodactylus spectabilis		1		1	1					1	2	6	4						-2	-5	-3			
Notolabrus celidotus	2	1		2			1	3	3	5	2	11	4	2		2	-1	-4	-2	-9	-4	-2	1	1
Nemadactylus macropterus					1				1				5				-1				-4			
Parapercis colias	6	2	3	1	1	1	8	8	9	3	5	6	7	5	10	12	-3	-1	-2	-5	-6	-4	-2	-4
Scorpis lineolatus		6		2	3					2		21	3					4		-19				
Scorpaena papillosa	2	2		1	1	1			4	3	2	1	2	1	1		-2	-1	-2		-1		-1	
Notolabrus fucicola		2			2			1		2		2	3		1					-2	-1		-1	1
Pseudolabrus miles	2	7	2	9	5		3		4	11		7	7	4	3	3	-2	-4	2	2	-2	-4		-3
Odax pullus																								
Chironemus marmoratus												1								-1				
Latridopsis ciliaris		2										1				1		2		-1				-1
Aplodactylus arctidens												1								-1				

	2019 survey transects								2016 survey transects								Difference							
Taxa	**1**	**2**	**5**	**3**	**6**	**4**	**7**	**8**	**1**	**2**	**5**	**3**	**6**	**4**	**7**	**8**	**1**	**2**	**5**	**3**	**6**	**4**	**7**	**8**
Hypoplectrodes huntii					1																1			
Forsterygion varium	1	4					1	1	3	8	1	16	6	3	4	3	-2	-4	-1	-16	-6	-3	-3	-2
Forsterygion lapillum									1		3						-1		-3					
Forsterygion flavonigrum									1								-1							
Ruanoho whero								1					1								-1			1
Forsterygion malcolmi		1			1								1		1			1					-1	
Notoclinops segmentatus										1								-1						
Forsterygion maryannae												2								-2				
Myliobatis tenuicaudatus														1								-1		

Appendix 3. Occurrence of taxa across the three Town Reef transects. "Y" designates the observation of the taxon at some point along the transect, as identified by diver notes or from the compiled photographic record for the dive.

Taxon	Common name / description	TR1	TR2	TR3
Phaeophyceae	**Brown algae**			
Ecklonia radiata	Kelp	Y	Y	Y
Rhodophyta	**Red algae**			
Corallinales	Coralline paint	Y	Y	Y
Plocamium cirrhosum		Y	Y	Y
Rhodymenia sp. A	Small red blade algae	Y	Y	Y
Rhodymenia sp. B	Red algae foliose	Y	Y	Y
Crustose algae cf. *Hildenbrandia*	Red encrusting algae	Y	Y	Y
Porifera	**Sponges**			
Ecionemia alata	Grey vase sponge	Y	Y	Y
Cliona cf. *celata*	Yellow boring sponge	Y	Y	Y
Red encrusting cf. *Stylopus australis*	Red cratered encrusting		Y	
Orange encrusting cf. *Tedania* sp.	Orange encrusting sponge	Y	Y	Y
Orange massive cf. *Hymeniacidon* sp.	Orange massive sponge		Y	Y
Tethya bergquistae	Pink golf ball sponge	Y	Y	Y
Tethya burtoni	Orange golf ball sponge	Y	Y	Y
Ciocalypta sp.	Yellow tubular sponge	Y	Y	Y
Lobed grey cf. *Thorecta* sp.	Lobed grey sponge			Y
Raspalia topsenti	Orange finger sponge		Y	Y
Pink Demospongiae C	Pink thick encrusting sponge	Y	Y	
Lilac Demospongiae D	Lilac spiky sponge	Y	Y	Y
Latrunculia cf. *procumbens*	Green mushroom-like sponge		Y	
Grey encrusting cf. *Ircinia novaezealandiae*	Grey encrusting sponge	Y		
Grey massive cf. *Suberites perfectus*	Smooth grey sponge	Y		Y
Globose sponge cf. *Aaptos globosa*	Globose sponge	Y	Y	Y
Branching sponge cf. *Iophon minor*	Cream branching sponge		Y	Y
Pale orange massive	Pale orange massive sponge		Y	Y
Bryozoa	**Bryozoans**			
Bryozoan Catenicellidae	Clowns hair/moss bryozoan	Y	Y	Y
Orange bryozoan cf. *Steginoporella*	Orange tube bryozoan		Y	Y
Encrusting cf. *Parasmittina delicatula*	Encrusting bryozoan	Y	Y	
Cnidaria	**Hydroids, anemones, corals**			
Feather hydroid cf. *Aglaophenia* sp.	Feather hydroid	Y	Y	Y
Amphisbetia bispinosa	Mussel beard hydroid	Y		Y
Branching / bushy hydroid	Bushy hydroid			Y
Ectopleura sp.	Solitary hydroid			Y
Anthothoe albocincta	White-striped anemone			Y

Alcyonium cf. *aurantiacum*	Common soft coral		Y	
Culicia rubeola	Colonial stony coral	Y	Y	
Corynactis australis	Jewel anemone	Y	Y	Y
Fine hydroid (on *Ecklonia*)		Y	Y	Y
Cnidarian small green	Cnidarian small green	Y	Y	Y
Polychaeta	**Polychaete worms**			
Serpulidae	Calcareous tube worm	Y		
Ascidiacea	**Tunicates, sea squirts**			
Pyura spinosissima	Sea tulip	Y		Y
Cnemidocarpa sp.	Saddle squirt	Y	Y	Y
Ascidiacea sp. A	Small red-mouthed ascidian	Y	Y	Y
cf. *Synoicum otagoensis*	Grey colonial ascidian	Y	Y	Y
Eudistoma sp.	White colonial ascidian	Y	Y	Y
Cream colonial ascidian cf. *Didemnum*	Cream colonial ascidian	Y	Y	Y
Didemnum sp. (white)	White didemnum	Y	Y	Y
Bivalvia	**Clams**			
Perna canaliculus	Green-lipped mussel	Y		Y
Ostreidae sp.	Flat oyster	Y		
Gastropoda	**Snails, sea slugs**			
Trochus viridis	Green top shell	Y	Y	Y
Calliostoma punctulatum	Beaded top shell		Y	
Cookia sulcata	Cook's turban shell	Y	Y	
Buccinulum linea	Lined whelk	Y	Y	
Xymene sp.	Whelk	Y		Y
Cabestana spengleri	Spengler's trumpet shell	Y		Y
Maoricolpus roseus	Turret shell		Y	Y
Whelk unid	Unidentified small whelk	Y	Y	Y
Ceratosoma amoenum	Clown nudibranch	Y	Y	Y
Nudibranch (unid)	White nudibranch		Y	
Cephalopoda	**Octopus, squid**			
Octopus maorum	Octopus	Y		
Crustacea	**Crabs, lobster, barnacles**			
Jasus edwardsii	Crayfish	Y	Y	Y
Pagurus sp.	Hermit crab		Y	
Echinodermata	**Sea cucumbers, seastars, urchins**			
Australostichopus mollis	Sea cucumber		Y	Y
Patiriella regularis	Cushion star	Y		Y
Pentagonaster pulchellus	Biscuit star	Y	Y	Y
Astrostole scabra	7-armed seastar	Y	Y	Y
Coscinasterias muricata	11-armed seastar	Y		
Evechinus chloroticus	Kina	Y	Y	

Osteichthyes	**Fish**			
Cheilodactylus spectabilis	Red moki	Y		
Notolabrus celidotus	Spotted wrasse	Y	Y	Y
Parapercis colias	Blue cod	Y	Y	
Notolabrus fucicola	Banded wrasse	Y	Y	
Pseudolabrus miles	Scarlet wrasse	Y		
Odax pullus	Butterfish/Green bone	Y		
Chironemus marmoratus	Kelpfish/Hiwihiwi	Y		
Aplodactylus arctidens	Marble fish	Y		
Forsterygion varium	Variable triplefin	Y	Y	Y
Forsterygion lapillum	Common triplefin			Y
Ruanoho whero	Spectacled triplefin	Y	Y	